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Heavy Railway Work Along the Des Chutes River, in Oregon.

That part of the State of Oregon which lies east of the great range of the Cascade Mountains is practically devoid of railway communication, but two important and directly competitive lines are now being built and it appears probable that there will be a large amount of railway construction work within this region during the next few years.

The central part of the state consists of a tableland or plateau at an elevation of about 3,000 ft. above sea level, or 2,850 ft. above the level of the Columbia River at the mouth of the Des Chutes River. It is flanked by mountain ranges, and the Cascade Range forms a complete barrier against railway access from the western part of the state. A large part of the plateau is available for agricultural development, and extensive irrigation works are in progress at some points. The drainage of the northern portion is towards the Columbia River; that of the southwest portion is towards California, with streams flowing to the Klamath Lake district; to the east there are the Malheur and Owyhee rivers, both tributaries of the great Snake River.

Available routes to this tableland are very few, owing to the abrupt and largely unbroken character of the faces, while the west side is shut off entirely by the Cascade range. The means of access are mainly by way of the Des Chutes River valley from the north, the Klamath River valley from the south, and the Malheur River valley from the east.

At the present time two railways are building southward from the Columbia River up the valley of the Des Chutes River, much of the work being in a narrow and winding canyon, involving heavy construction. These are the Des Chutes Ry., of the Harriman system, and the Oregon Trunk Ry. of the Hill system. The former keeps entirely to the east side of the canyon. The latter keeps mainly to the west side, but crosses twice to the east side in order to avoid heavy construction and to shorten the distance. During early stages of the work, the interference between the two lines more than once threatened to result in physical encounters of the rival forces, but happily these were avoided. The question of the respective rights of the two companies was submitted to the courts, and as a result of the decision the Des Chutes Ry. will make use of two stretches of the Oregon Trunk Ry., one 12 miles and the other 20 miles in length. The fact that one of two rival lines found it necessary to make joint use of the right-of-way of the other line indicates the difficulties of location along this river. Fig. 1 is a view showing the two railways at a point near Free Bridge, in the lower part of the river; the Des Chutes Ry. is on the right and the Oregon Trunk Ry. on the left.

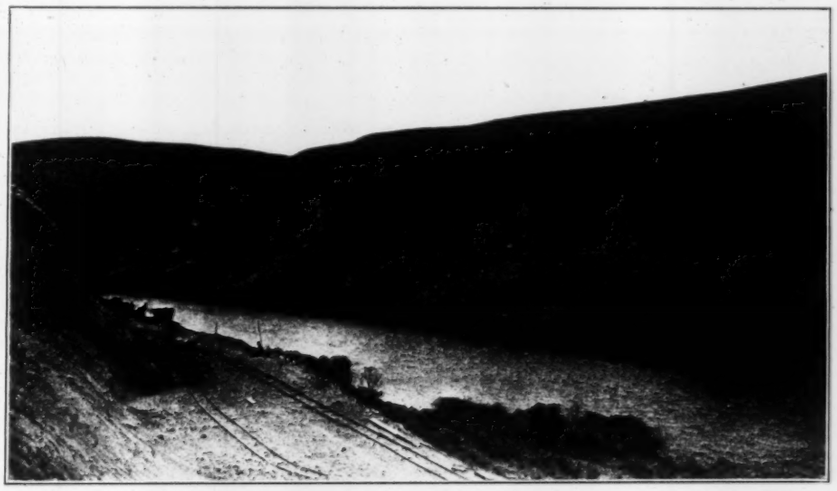

FIG. 1. THE PARALLEL LINES OF THE DES CHUTES RY. AND THE OREGON TRUNK RY. IN THE CANYON OF THE DES CHUTES RIVER; OREGON.

(Copyright by B. B. Bakowski, Bend, Ore.)

A map of the two lines and some of the projected southern and eastern extensions is shown in Fig. 2. Eventually there will be an important line north and south, paralleling the existing lines on the west side of the range which form part of the route between San Francisco and Portland. Undoubtedly, also, there will be at least one main line eastward across the state. A main line of the Oregon Ry. & Navigation Co. extends across the northeast corner of the state from the Columbia River to the Snake River, and on the south the Southern Pacific Ry. has pushed a line up from California into the Kalmath Lake district. It will be seen that three short lines extend south from the Columbia River, each following a river valley, but these do not reach the tableland, and they have such steep grades and other unfavorable features that they cannot be used as parts of main lines. The lines up the Des Chutes River, however, are being built as important main lines and not as local lines. Practically all the railways shown are parts of the Harriman system, with the exception of the Spokane, Portland & Seattle Ry. along the north bank of the Columbia River, which belongs to the Hill system and forms the connection for the Hill line up the Des Chutes River to central Oregon.

The Des Chutes River is said to have an exceptionally uniform flow. The available waterpower at its various falls is estimated at 900,000 HP., while that of the other streams in its drainage area brings the total up to 1,115,000 HP. The construction of the railway will reduce these amounts to about 760,000 and 925,000 HP. At three points on the lower part of the river the two railways have raised their grades so as to permit of the building of three dams, at which about 140,000 HP. can be developed: (1) the Moody's Dam (140 ft. high above the river, 67,500 HP.), two miles from the river's mouth; (2) the U. S. Government Dam (100 ft. high, 46,000 HP.), 20 miles up the river; and (3) the Sherars Dam of the Interior Development Co. (60 ft. high, 27,000 HP.), 40 miles up the river. These are shown in Fig. 3. The minimum discharge of the river at these dam sites is about 5,000 sec.-ft., as shown by the water-supply papers of the U. S. Geological Survey. Between this last dam and Trout Creek, the railway construction will necessitate the use of flumes or pipe lines for power development. The development of irrigation will reduce the flow available for power, but it is estimated that allowing for reductions due to railway construction and irrigation work there will be available about 430,000 HP. on the Des Chutes River, and 630,000 HP. on this river and its tributaries.

The Des Chutes Ry.

The Des Chutes Ry., which is being built in the interests of the Oregon Ry. & Navigation Co., commences by a junction with this company's line on the south bank of the Columbia River at Des Chutes, near the east side of the mouth of the Des Chutes River (Fig. 3). This point is about 106 miles east of Portland and 327 miles west of Spokane. The railway lies along the east bank of the river for about 85 miles and

then turns east up the valley of Trout Creek, crossing this stream. It then rises out of the valley to the elevated plateau following a course generally southward to Madras (100 miles) and Redmond (130 miles). For about 12 miles north of the Trout Creek crossing there was a dispute with the parallel Oregon Trunk Ry. as to the ownership of the location, but this has been made a joint line since May, 1910. A profile of the line is given in Fig. 3. The elevations above sea level are as follows: 162 ft. at the Des Chutes junction; 1,255 ft. at the Trout Creek crossing, 2,440 ft. at Madras (200 ft. above the town), and 3,000 ft. at Redmond.

In the canyon of the Des Chutes River, the line follows the windings of the stream very closely, and it is kept a little above the level of flood water in the river. Figs. 4 to 7 show the character of the work encountered. The maximum grade here is 0.8%, but this grade is practically continuous for a considerable proportion of the distance. The curvature amounts to 9,860°, the sharpest curves being 12½°, while curves of 10° and over aggregate about 820°. The curves are spiraled according to the standard system for the Harriman lines, compounding each 30 ft. up to the main curve; this was described very fully in our issue of Oct. 28, 1909. The compensation of grades for curves, with a maximum grade of 1.5% on tangent, is 0.035% per degree up to 6°, 0.045% per degree up to 8½°, and 0.050% per degree up to 10°. No reduction of grade is made in the tunnels.

At the three dam sites mentioned above, the location is on a supported grade of 0.8%. On the 16.5 miles of 1.5% supported grade between Trout Creek and Madras (see Fig. 3), the tributary drainage of Trout Creek (which is followed) and breaks through the rim rock in two places where the grade is kept just above high water, giving a little slack grade just before reaching each break. This divides the grade as follows: from Summit, near Madras, 1.5% for 3.5 miles, then 9 ft. slack; then six miles between the rim-rock breaks, for a portion of which the grade is somewhat over 100 ft. above the drainage. A view on this part of the line is shown in Fig. 8. At the second break, 2.86 ft. of slack grade is introduced to keep the grade above high water of drainage. Soon after leaving the second rim-rock break the 1.5% grade is supported about 100 ft. above the drainage and continues above it until after crossing Trout Creek 100 ft. above water, the last stretch of 1.5% grade being seven miles long. At the two points where slack grade is introduced stations have been established, making the slack grade specially acceptable.

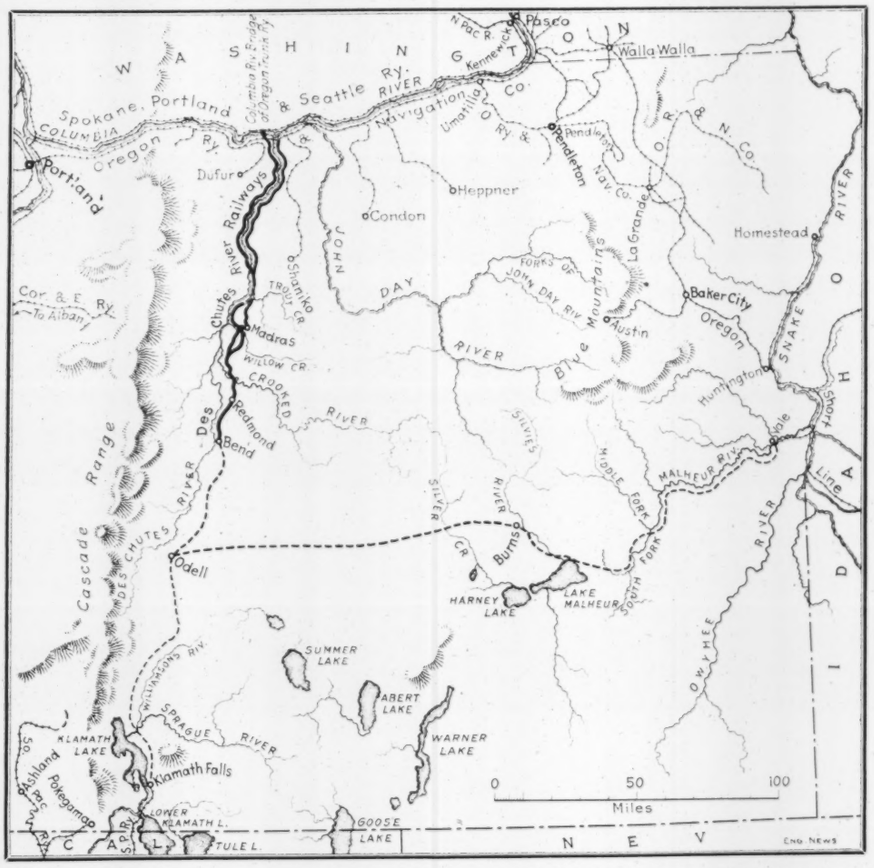

FIG. 2. MAP OF EASTERN OREGON, SHOWING THE RELATION OF THE RAILWAYS NOW BEING BUILT UP THE DES CHUTES RIVER TO THE EXISTING RAILWAYS AND THE GREAT CENTRAL PLATEAU.

There are five tunnels along the river, from 150 ft. to 1,175 ft. in length. After crossing Trout Creek by a steel viaduct 540 ft. long and about 400 ft. above the water, there is a continuous climb by a grade of 1.5% to Madras, with a large proportion of curved track ranging from 4° to 10°. There is one 500-ft. tunnel on this grade. Between Madras and Redmond the maximum grades are 0.5% northbound and 1% southbound, with considerably less curvature, most of the curves being under 4°. On this part of the line is the only grade (0.5%) against northbound traffic.

Near Madras, the line crosses Willow Creek by a steel viaduct 1,050 ft. long, about 250 ft. above the water, and 200 ft. above the Oregon Trunk Ry., which it crosses. The location is shown by the dotted line in Fig. 9, and the design of the structure is shown in Fig. 10. The Trout Creek Viaduct has four tower spans of 40 ft., and seven girder spans, while at each end is a single-bent between the abutment and first tower. The maximum height is 80 ft. from top of pedestal. Owing to the steep slope of the ground transversely to the bridge at the west side of the valley two of the bents have one leg very much longer than the other, as shown in Fig. 11. Before reaching Redmond there is a 360-ft. bridge over Crooked River, having a height of about 350 ft. above the water, but this will be built by the Oregon Trunk Ry. The bridges are designed for a loading of two 395,000-lb. compound consolidation locomotives (2:8:0), followed by a net load of 5,000 lbs. per ft. of track.

Along the Des Chutes River, the excavation is mainly in hard volcanic rock, much of which requires blasting in advance of the steam shovels. In fact, out of 2,500,000 cu. yds. of excavation for the cuts, only 300,000 cu. yds. are of material that can be handled without blasting. In addition, there will be about 400,000 yds. of rock and the same amount of earth borrowed for filling. The tunnels are in basaltic rock of varying

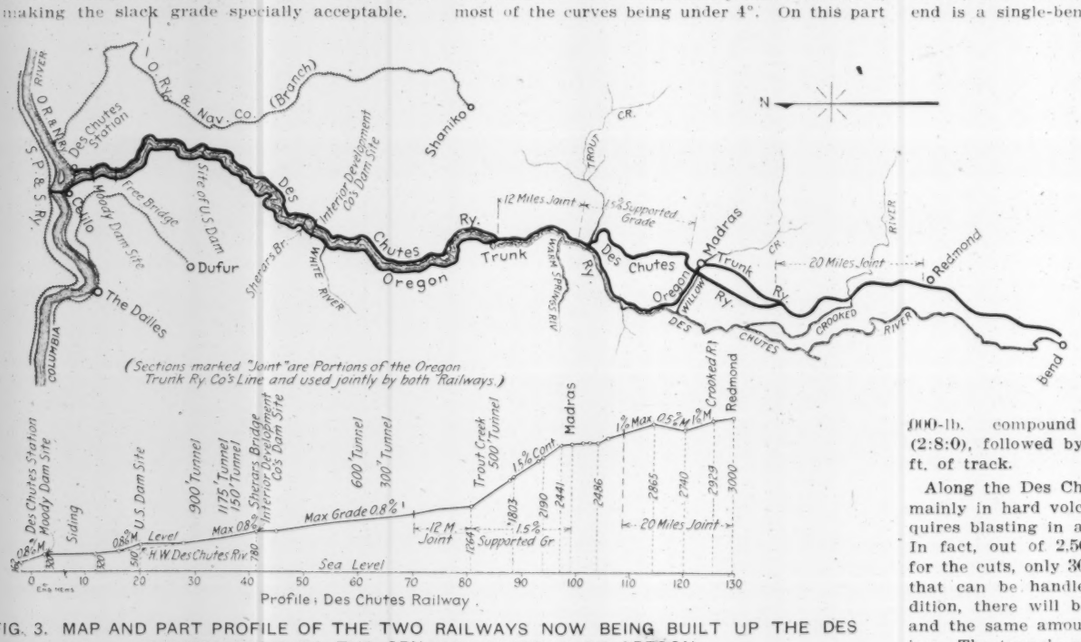

FIG. 3. MAP AND PART PROFILE OF THE TWO RAILWAYS NOW BEING BUILT UP THE DES CHUTES RIVER TO THE CENTRAL PLATEAU OF OREGON.

hardness. They are driven by hand drills, being too difficult of access to make it economical to install power plants. The progress averages 100 ft. per month at each heading. The tunnels are timbered, and future concrete lining is proposed. Small drainage openings in embankments up to 20 ft. high are formed by corrugated metal pipe culverts 24 ins. and 32 ins. diameter. Concrete arches will be used for culverts up to 20-ft. span, but during construction timber structures are provided for these openings.

Construction plant and material was delivered at points along the Shaniko branch of the Oregon Ry. & Navigation Co., which practically parallels the Des Chutes; it was hauled across country to the latter canyon and then lowered to the level of the new line by skidways or hauled down wagon roads of 20% grade, built along the side of the canyon at considerable expense.

The width of the roadbed is 14 ft. on banks and 16 ft. in cuts, the tunnels are 17 ft. wide in the clear, and have a center height of 24 ft. from the subgrade, or 22 ft. 6 ins. from base of rail. The track is laid with 75-lb. rails of the standard section of the Harriman Lines, on untreated ties 7 × 8 ins., 8 ft. long. Flat-bottom shouldered tie-plates are used on curves. By the middle of May, 1910, about 75 miles had been graded, 20 miles of the track laid, and two of the tunnels completed. It is expected to have the line in operation as far as Madras by November. The average cost of the line, including tunneling and bridging, is estimated at $45,000 per mile; along the Des Chutes River, however, the cost is about $60,000 per mile.

The line is being built by the Des Chutes Ry. Co., a subsidiary of the Oregon Ry. & Navigation Co. Mr. Geo. W. Boschke is Chief Engineer, and the work is divided into 12 residencies. The general contract is held by John Twohy, of Spokane, Wash. About 3,500 men and five steam shovels are now at work. The contract for the large steel bridges over the Trout Creek and Willow Creek have been placed with the American Bridge Co. The tracklaying is done by the railway company, which also builds its trestles and timber structures.

The Oregon Trunk Ry.

The Oregon Trunk Ry. is being built in the interests of the Hill System. From a connection with the Spokane, Portland & Seattle Ry., recently built along the north bank of the Columbia River (Eng. News, Feb. 13, 1905), it will cross the river at Celilo about four miles west of the mouth of the Des Chutes River (114 miles from Portland and 260 miles from Spokane), and then enter the canyon of the latter river. It follows the west bank for about 75 miles, except for about one mile at Sherars Bridge (where it crosses to the east side and back again to avoid heavy tunneling and to decrease the distance). The location is shown in Fig. 3.

At about 75 miles from Celilo the line crosses again to the east bank and follows this for 12 miles to Trout Creek. This location was in dispute with the Des Chutes Ry., but the question of the rights of the two roads has been settled by the courts in favor of the Oregon Trunk Ry., and an agreement has been made by which the former line will have joint use of the latter's track, as above noted. Crossing Trout Creek the line continues along the east bank of the Des Chutes River to Willow Creek, and follows the latter, gradually rising out of the canyon to the elevated plateau which it reaches at Madras (111 miles), at which point the line is 200 ft. lower than the Des Chutes Ry. It crosses Willow Creek here and will run thence to Bend, 150 miles from Celilo, and south to the Klamath Lake district in the southern part of the state. Extensions eastward and southward are projected, to open up a great area of central and southern Oregon which at present has no railway facilities.

The maximum grade is 0.06% for 95 miles along the Des Chutes River, but in the Willow Creek canyon it is 1.3%. There is a large proportion of curvature, but the sharpest curves are 6°. Along the Des Chutes River there will be six tunnels, with three additional tunnels later to shorten the permanent line. These are from 200 ft. to 800 ft. in length.

The Columbia River bridge will be about 3,957 ft. long, including approaches; it will have five 75-ft. deck plate girder spans, one 300-ft. draw span, one 320-ft. through truss, six through truss spans of 230 ft. and 16 deck plate girder spans of 102 ft. The Des Chutes River will be crossed twice near Sherars Bridge by bridges having one through truss span of 160-ft. and three 75-ft. deck plate girders; the bridge at the third crossing of this river will have two 165-ft. spans. Timber trestles aggregate only about a mile in length, and these will be filled later. Timber structures are used for the larger drainage openings, but permanent concrete arched culverts are provided for later, excepting that the smaller culverts on about ten miles of the line are of corrugated metal pipe, 18 ins. to 5 ft. diameter.

Along the Des Chutes River the work is largely in hard volcanic rock, alternating with talus slopes or with comparatively level land. A view of a difficult stretch of work, with a piece of roadbed commenced is shown in Fig. 12. The grade is kept well above the flood level of the river. All the tunnel work is being done by hand drills. Construction material and supplies were brought by rail from Des Chutes (on the Oregon Ry. & Navigation Co.'s line); also by wagon from Dufur, the end of a branch line west of the Des Chutes River, and from Shaniko, the end of a branch line east of that river. From Celilo to Madras there will be about 6,000,000 cu. yds. of excavation in the cuts, and 1,000,000 cu. yds. of additional borrow for the fills. Half of this work is solid rock, and the balance loose rock and hard pan. The width

Fig. 4. Mile 32, Looking North.

Fig. 5. Mile 35, Looking South.

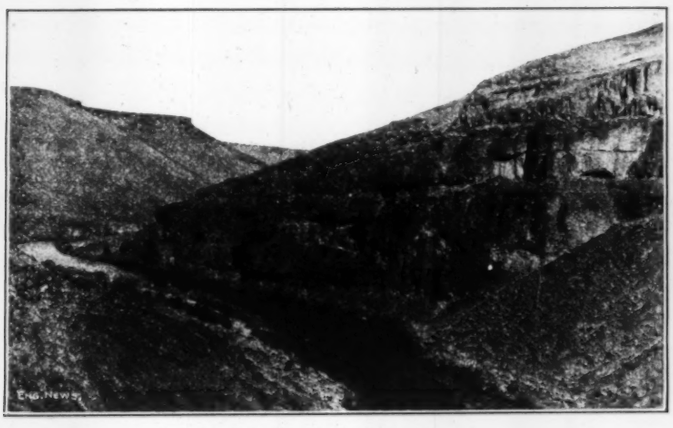

Fig. 6. Mile 57 1-2, Looking North.

Fig. 7. Mile 73.2, Looking South.

VIEWS ALONG THE DES CHUTES RY. IN THE DES CHUTES RIVER CANYON, OREGON.

of roadbed is 18 ft. and 16 ft. on earth and rock banks, 24 ft. and 20 ft. in earth and rock cuts. The tunnels are 16 ft. wide in the clear, with a center height of 23 ft. above the base of rail. The track is laid with 90-lb. rails of the Am. Soc. C. E. section, with tie-plates on all ties on curves and short tangents. Up to the end of June, 1910, about 80% of the line had been graded, but no track laid. It is expected to have the line completed to Madras by December.

The line is being built by the Oregon Trunk Ry., an independent company (but in the interests of the Hill System). Mr. John F. Stevens, M. Am. Soc. C. E., is President; Mr. G. A. Kyle, Assoc M. Am. Soc. C. E., is Vice-President and Manager, and Mr. Ralph Budd is Chief Engineer. There are four district engineers and 13 residencies of 7 to 8 miles in length. The general contractors for the work from Celilo to Madras are Porter Brothers, of Spokane, Wash., who have about 4,500 men and two steam shovels at work. The contract for the substructure of the Columbia River bridge has been let to the same firm, but the contracts for the three bridges over the Des Chutes River and the superstructure of the Columbia River bridge have not been let. The tracklaying will probably be done by Porter Brothers.

The contract for the work from Madras to Bend, a distance of 47 miles, has been awarded to H. C. Henry, of Seattle, Wash. The work is very light compared with that of the line between Celilo and Madras. There will be a steel arch bridge across the Crooked River 350 ft. span and 350 ft. high, and the location of this is shown in Fig. 13. On the remainder of the line there are scarcely any bridges. After the line reaches Madras it passes through a good farming country. From the Crooked River to Bend, 25 miles, the land is under irrigation by the Des Chutes Irrigation & Power Co. A district engineer and six resident engineers are on the last piece of line.

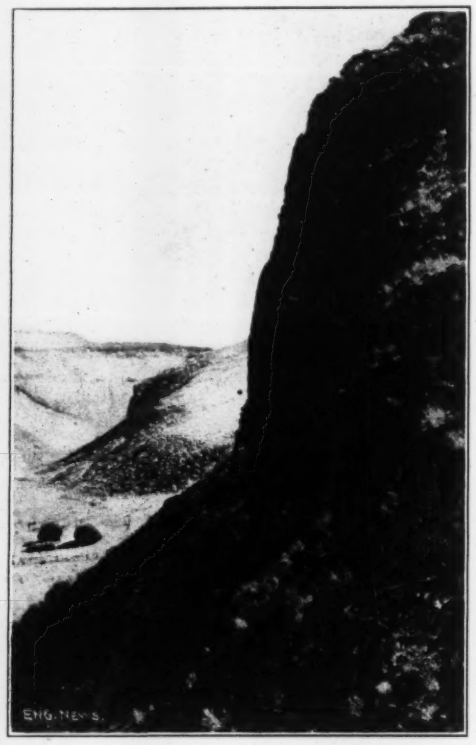

Fig. 8. View at Mile 85.3, Des Chutes Ry.
(The line is supported 100 ft. above drainage level.)

The Harbors of Great Britain, with Some Reference to Those of North Europe and North America.*

By J. V. NIMMO,† M. Can. Soc. C. E.

The author proposes in the following paper to attempt to study very briefly and in general principles only, the harbors of Great Britain as they exist to-day, and still more briefly and by way of comparison, those of Northern Europe and North America; to touch on the organization whereby the harbors are administered; to deduce some of the main principles which underlie their design; to point out some of their chief deficiencies; and to suggest the lines on which it seems to him improvement might best be carried out.

*A memorandum prepared for the Sociological Society of Great Britain at the request of the Secretary.

†Division Engineer, Canadian Northern Railway, Lytton, B. C.

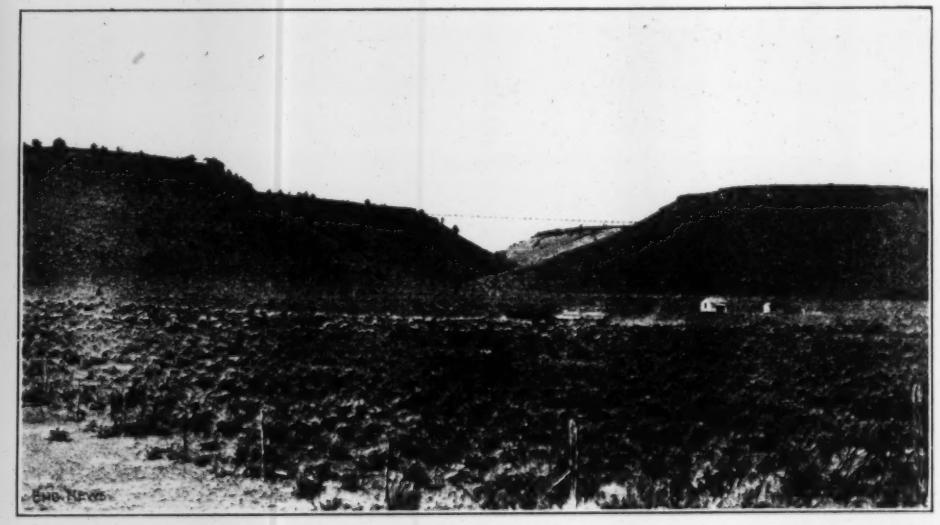

FIG. 9. LOCATION OF THE WILLOW CREEK VIADUCT OF THE DES CHUTES RY., OREGON.
(The Oregon Trunk Ry. passes under the viaduct, following up the valley.)

The essential constituents of a harbor are:

1. An entrance, so protected either naturally or artificially that vessels can enter the harbor in any state of the weather.

2. Facilities for berthing vessels, i. e., the provision of accommodation where they can lie while carrying out the operations of transferring cargo from ship to railway or road wagon, and vice versa, and protected anchorage, i. e., facilities for mooring the vessels so that they can lie in safety awaiting their berths or undergoing repairs, etc.

In general harbors may be classified as:

1. Fluvial, i. e., harbors constructed on the banks of a river which can be entered safely in any state of weather, either because of natural advantages (e. g., the St. Lawrence River), or because of artificial protection (e. g., the Tyne).

2. Formed on sea inlets, for example, Halifax, N. S.; Southampton; Sydney, Australia, etc.

3. Entirely artificial, as Manchester, Seaham Harbor, Le Havre.

The design of harbors is to a large extent dependent on the trade for which they are intended. The question of entrance provision for the mooring of vessels, and to some extent the arrangement of the quay are common to all, but modification of details in the berths are introduced for special cargoes, e. g., for coal, ores, etc., and the arrangement of the quay itself differs materially for different kinds of business. Again, the design is affected by the mode in which the cargo is brought to and taken from the ocean-going vessels, whether by road, railway or barge.

The Harbors of Great Britain.

We will now briefly consider the harbors of Great Britain, treating the question under the two heads (a) Entrance; (b) Inner Dock, which includes berthing and mooring facilities:

THE ENTRANCE.—Nearly all the British harbors of consequence are situated on rivers which in many cases man has converted from what was originally often little better than a stream into a mighty channel, two of the most striking instances being Liverpool and Glasgow. This is a question of dredging and river training, and is one which is both well understood and carried out. It is the only instance in harbor work where the work done to-day will beyond all doubt help the needs of to-morrow, for the deeper one dredges the channel the nearer perfection does it become. There are, however, river mouths so exposed as to require the construction of massive piers to protect them from heavy seas in order to make the approach possible in bad weather, the River Tyne being a good instance. And again there are harbors which, owing to special circumstances, have been constructed where there are no natural advantages whatever, two such being Dover and Seaham harbor. Here piers were constructed right into the sea itself, leaving a protected opening of sufficient width to allow vessels to pass through even in rough weather, and giving quiet water inside, so that the inner harbor, which was carved out of the solid land, or built upon what was originally beach could be easily and safely entered.

THE INNER DOCK.—Now having entered the river, or sea inlet, our ship requires a place where she can unload her cargo or take on a fresh one. In some ports such berths are constructed along the river bank itself. In fact, in most of our British ports some of the shipping is handled in this manner, notably in London and Glasgow; but chiefly this is confined to coast shipping, and where the freight is handled by horse wagon instead of railway. More frequently, at least for ocean-going steamers, inner docks are provided, which are really ponds of the required depth, to which the vessel proceeds through a more or less narrow entrance, sometimes protected by gates and sometimes not. The purpose of the gates is to keep the water in the inner dock at a continuous level, where the river or other outside water area has a high tidal rise. If it is desired that the dock should be entered at any stage of the tide, then instead of a single pair of gates there must be two pairs, separated by more than a ship's length, thus forming a lock.

The inner dock is generally of a rectangular shape, more or less square. As a rule, the vessels lie against the walls, which form the sides of the dock, parallel to which are the railway and train tracks and transshipment sheds; but in some cases, as in Liverpool and Tilbury, piers jutting out into the main dock area form the berths; and on these piers are placed the railway and crane tracks and the sheds. The writer has never been able to form a proper explanation as to why these older inner docks are so square in shape, but believes it to have been due partially to the comparatively large area required for manoeuvring the sailing vessels (for which these old docks were built) to and from the berth, partially to the fact that sailing vessels would lie up for considerable periods between voyages and require room in the middle of the dock for that purpose, and partly, perhaps, to the original idea that the wet dock (as it is called in contra-distinction to the dry dock for repairing purposes), should be a kind of inland lake or area of water. This latter idea can be traced in the unit still commonly used in Great Britain whereby docks are compared, namely, the acre.

It is now being recognized, however, that since the modern steamer is too expensive a machine

to allow idle a moment longer than is necessary, laying-up accommodation is a secondary consideration, whereas the provision of the maximum berthing accommodation possible, i. e., quay frontage, is the governing feature, and only so much open water area is required as is absolutely necessary to manoeuvre vessels to and from the berths with the least amount of laying-up area that is practicable. Hence, in the more modern docks one finds the berths are formed by piers jutting out into the main deck, or by long narrow docks, as at Manchester, and the new docks at Avonmouth and Swansea.

With a general or mixed cargo very little can be put direct into wagons for the final destination, nor is there much which can be put direct from the wagon to ship hold. Hence arises the need for the transshipment shed parallel to the berth, and not far from the quay edge. Into this freight is unloaded from wagon or ship and sorted for its final destination, whether that be ship or wagon. This shed also answers as a kind of temporary store where freight is collected to wait for the ship, or is hurriedly thrown out of the hold to await the railway wagon. In Europe it is almost universal to find wharf cranes for unloading and loading the ship, of light capacity but quick action. Where railway tracks exist between the quay side and the shed, these cranes run on special tracks and are so arranged that wagons and locomotives can pass underneath them; but where no such quay-front track exists, as at Liverpool, they are placed on the shed roof. Transshipment sheds are of one or more stories, and vary in construction from the flimsiest wooden structure to the most modern reinforced-concrete building.

To distribute the freight to the various final destinations, and per contra to collect it from the inland shipping centers for the ship, good railway communication is a primary necessity in a modern harbor. Hence we find that railway tracks are constructed either behind or in front of the transshipment sheds, and sometimes both behind and in front; and these tracks are led to large railway yards where the trains are made up for dispatching, or are broken up on arrival from inland points and the cars sorted for the various berths. Sometimes there are small subsidiary yards close to the sheds where any minor sorting of the wagons can be carried out. The old harbors, however, existed before railways, or at any rate before the possibilities of the modern traffic development were realized, and railway connection has had to be made over valuable property, and in consequence railway communication in many of the main ports is in poor condition. Hardly a single one of these older ports has adequate or well-equipped marshalling yards, or communication with the transshipment sheds, which can be easily kept continuously open.

Liverpool is an instance of such failure. The track leading from the main yards of the various railway companies to the berths is carried along the roadway, which is often crowded with vehicular traffic. This track is but little used, and the great bulk of the traffic is transferred to and from the railway yards or the various storage warehouses, by horse wagon. As a contrast to this, attention is drawn to Tilbury Docks, which, although some 25 years old, are farther advanced than most other docks in the Kingdom from the point of view of railway yards and accommodation, probably because the engineer designing it had a large area of virgin territory to work on, and was not hampered by any restrictions as to land or buildings. From the point of view of track arrangements at the berths themselves and carefully designed transshipment sheds, Manchester is perhaps the best equipped of modern harbors in Great Britain.

Mooring facilities are provided either in the river or outer harbor, or in the middle of the water area of the inner dock, but, as already explained, this feature has not to-day the importance it had in olden times.

So far we have treated only of ports handling a general cargo, and these are the most important in the Kingdom. But there are many ports which handle a particular kind of cargo only, and others which have a large specialized trade in addition to the general cargo, e. g., the South Wales and North of England ports, where coal is the main business. This has been already referred to in the earlier part of the paper. The difference between such ports and those which are intended for a general cargo lies chiefly in the special arrangements for loading and unloading the cargo, in the absence of transshipment sheds, and in the facilities provided for a cheaper construction of the sides of the dock, owing to the fact that ordinary perpendicular-faced walls are frequently not required.

In the case of coal, the loading is carried out either from the high-level staithes, using wagons with doors in the bottom, or by the use of hoists which raise and tip the ordinary ten-ton wagon, and an intricate system of gravitation lines for handling the full and empty trucks is installed; but the general principles of railway communication and yard accommodation are much the same as in the other harbors considered, and we need not for the present purpose deal any further with such special docks. Attention might be drawn, however, to the grain trade, which is carried on in almost every port of moment, and which necessitates the installation of movable bucket conveyors, which can be lowered into the ship's hold, and which transfer the grain to a system of belt conveyors connected with the storage bins.

Another feature which introduces a variety in the design of docks is the supplying and distributing of the freight by means of inland navigation. For example, Hull and Hamburg are the termini of two extensive and intricate systems of inland water navigation. It has usually been the custom to transfer such cargo direct from barge to ship and vice versa without landing the freight on the quays at all, and one frequently sees at Hull a vessel lying at right angles to the quay front with its bow or stern forming the only connection with the quay, thus giving ample water room for barges on each side of it. But apparently the economies to be gained by the use of a transshipment shed are making themselves recognized here also. Indeed in London at present much of the barge cargo is unloaded at or near the berth of the ship for which it is intended, where it lies in the transshipment shed till its place in the ship's hold is ready to receive it, and conversely with cargo which is to be distributed by barges. In Hamburg there has recently been constructed a transshipment shed on piles which has openings in the floor through which the contents of barges with cargo from the ocean vessel are unloaded into the shed. The goods are there sorted ready to be passed later on through the same floor openings into the inland navigation barges, and vice versa.

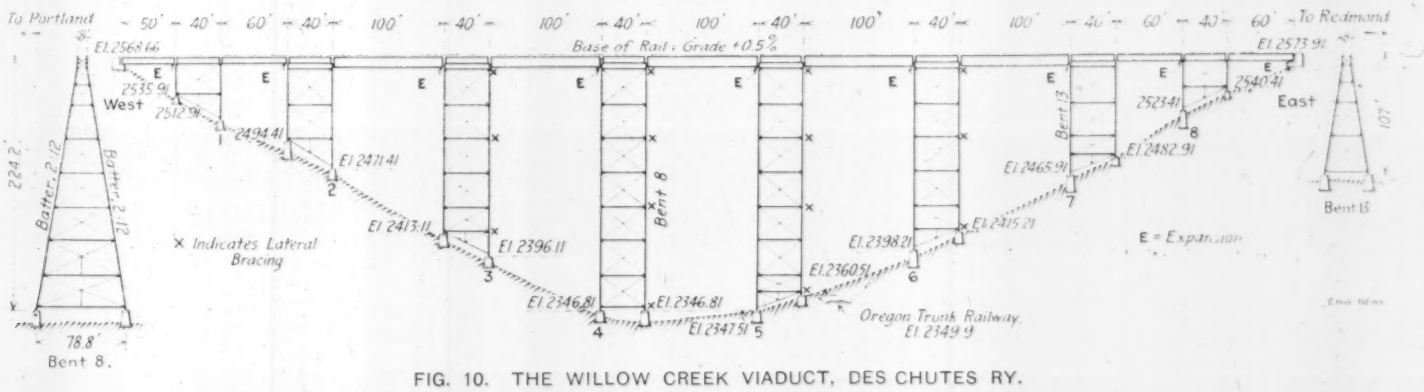

FIG. 10. THE WILLOW CREEK VIADUCT, DES CHUTES RY.

The Harbors of Northern Continental Europe and North America.

France has followed very closely the main features of early British design; the inner locks are large rectangular areas of water, almost square, generally entered by means of locks, with single story storage sheds, having their floor at rail level, and with tracks behind and in front, the whole very solidly and permanently built. She has in fact adhered more rigorously even than England to many principles which are now being recognized as obsolete. There is, indeed, very little to be learned as to general principles from French harbors, but much to be gained from their study from the point of view of engineering details, in which the French excel.

On the other hand, in Germany the recent rapid and enormous development of her shipping

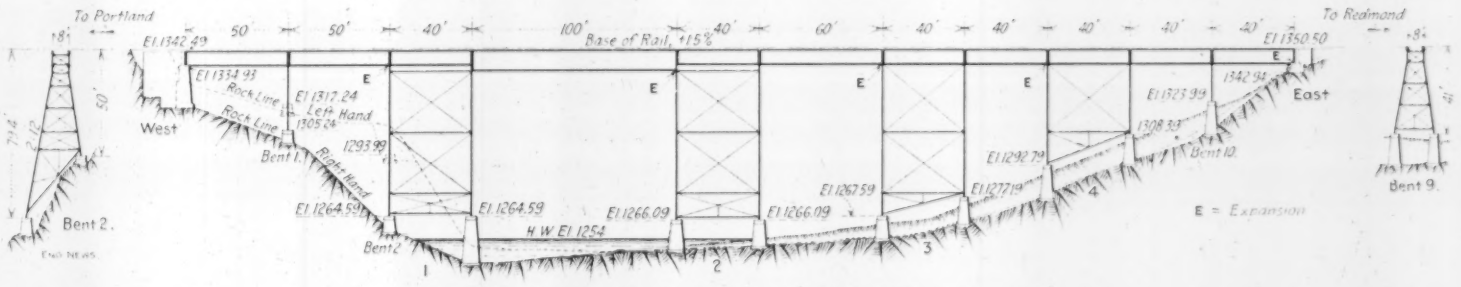

FIG. 11. THE TROUT CREEK VIADUCT, DES CHUTES RY.

has thrust the harbor problem forward in a more acute form, and the questions have been tackled with perhaps less regard to previous practice than was the case with France. We see in Germany designs better suited to modern requirements than in either England or France, except in the most modern docks of the former. The two most modern and largest German ports are Bremerhaven and Hamburg, both located on rivers, one near the mouth and the other a considerable distance inland. At Bremerhaven the tidal rise calls for entrance locks to the docks, and the general arrangement of the docks is very similar to the modern English dock, such as at Avonmouth or Hull; but the method of construction is somewhat cheaper, and the railway accommodation and transshipment sheds are splendid. At Hamburg, however, there being no tidal rise, there are no dock gates, nor, indeed, are there docks in the English sense of the word, but rather elongated areas of water excavated from the flats alongside the river, bounded by quays carrying magnificent shed and railway accommodation on what is virtually reclaimed land. The difference between these two German harbors is, indeed, rather striking, in so far as Bremerhaven is not unlike an English dock in its main design, while Hamburg is quite original, the mud flats on which the docks are built lending themselves to a cheap form of construction.

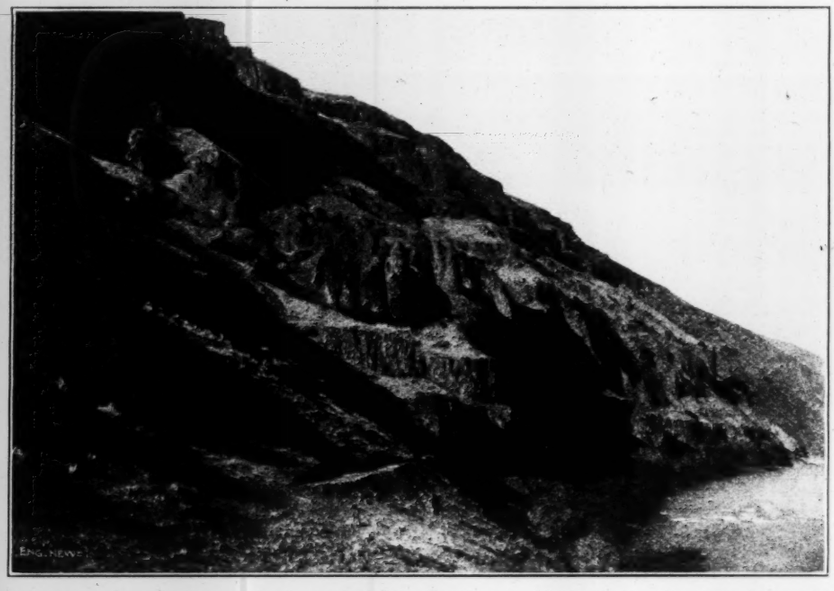

FIG. 12. DIFFICULT WORK ON THE OREGON TRUNK RY. ALONG THE DES CHUTES RIVER; OREGON.

Antwerp, the other Continental port of first magnitude, offers few original features, being designed more on French than German lines. It has both river quays and wet docks; and, although the former seem excellently planned and well provided with railways, they are not being extended, as it is found that there is a tendency for the river to deposit silt at the berths, making constant dredging necessary.

In the United States and Canada we find a still more striking illustration of a problem tackled without regard to precedent and by means suited to the then demands, but by methods in which the saving of first cost is of the greatest importance. Nature has, however, done so much in providing fully protected sea inlets, or large rivers, where the tidal rise is small, that man has had a comparatively easy problem in adapting them in shipping requirements. There has been, indeed, little to do except to construct the berth with the attendant transshipment sheds and railway tracks; but inasmuch as the design of these has been generally carried out by the engineers of the railway companies whose approach to tidewater was often the cause of the development of the harbors, the railway side of the question was given full consideration; in fact, the fundamental consideration (as it surely ought to be), which governed their deliberations, was how to transfer freight quickly and cheaply from railway train to ship and vice versa; and only in so far as it was a necessity for the attainment of this object, was the handling of the ship considered.

It is only in comparatively recent times that the purely harbor engineer has developed in America. As a result, the shipping facilities are on the whole more crude than in Europe, but the cargo can be handled as quickly and as cheaply when the difference in labor costs is considered, and at vastly less cost in original construction. In contrast to this, one might point out incidentally that in Europe the harbor engineer existed before the railway engineer, and has always predominated, and even ignored the railway man to some extent, and it is partially to this that the writer attributes the comparatively inferior traffic arrangements in the British harbors. The American system consists, briefly, in constructing pier berths jutting out into the natural harbor, or quay walls parallel to the shore line, with transshipment sheds running parallel to the berth, behind which are the railway tracks leading to the sorting yards for each group of berths, from which connection is made with the main yard. The tidal range being small, and the natural protection generally adequate, there is in most cases little to do to the harbor proper except some dredging.

Harbor Management.

GREAT BRITAIN.—The ports of Great Britain are in general owned and managed by public bodies, especially appointed for the purpose, such as the harbor trust at Liverpool and port authority at London; but in some harbors certain docks are privately owned by railway companies, and the river channel, and perhaps other docks, controlled by a public body, and again in other cases the whole organization is privately owned and controlled, for example, Seaham Harbor, Blythe, etc.

FRANCE.—Hitherto the whole management, as well as construction of French docks and harbors has been centralized in the hands of the National Government at Paris. There is a movement on foot to-day to place the management into the hands of local authorities, as is generally done in Great Britain, and it would certainly seem as if the operating departments had in the past been kept too strictly separate from the engineering department, and the design of the docks carried out on too academic lines.

GERMANY.—The German harbors are generally owned and operated by the local state, or the city, while the railways are in the hands either of the local state or the Imperial Government. That the result is fairly efficient speaks well for the German genius for organization, and their bureaucratic efficiency, but even here one can see that much could be gained by a comprehensive study of the harbor question as a whole.

AMERICA.—In the United States of America and in Canada, most of the principal harbors are managed by publicly elected bodies, although certain of the docks are owned and constructed by private interests.

Fundamental Principles.

Such being a brief description of things as they exist to-day, we will now endeavor to determine from these considerations what are the fundamental principles which underlie this harbor question, and point out the deficiencies in our British harbor as they strike the author, and to briefly consider the remedies that may suggest themselves.

It cannot be too strongly emphasized that, with the exception of a few particular instances, such as local fishing harbors, the harbor question cannot be considered without giving as much thought to the railway as to the ship. It is stultifying all initiative if, when economies revolutionizing the cargo steamer are introduced, when the means of rapidly, safely and cheaply bringing the ship to her harbor berth are being continuously improved, when the machinery for loading and unloading cargo to and from the hold is constantly being improved upon by the introduction of labor-saving devices, we find the means of transferring the cargo between ship and railway train so cumbersome and antiquated as to cost as much as if not more than the unloading of the ship itself.

We may summarize the operations involved as follows:

1. The bringing of the ship safely and speedily to her berth.
2. The unloading of the cargo from the ship's hold, and placing it in the transshipment shed.
3. The sorting of the cargo in the transshipment shed according to its inland destination, etc.
4. The loading of the cargo onto the railway wagon.
5. The rapid withdrawal of the loaded wagons, and the supplying of empty wagons in their place.
6. The removal of the loaded wagons to the main yard, and there marshalling them into trains ready for their inland destination. And the reverse of all these operations for outgoing cargo.

In the author's opinion, it is not until this last point has been reached that the harbor problem may be said to be complete, and the question become purely a railway one. Sometimes (2) and (3) are carried out in one operation; the cargo is placed directly on wagons beside the ship, and the transshipment shed is not used. It is but a small portion of the general run of cargo, however, that can be so treated.

As to (1), if nature provides either a wide river mouth with ample depth of water, or a well protected inlet of the sea, the harbor is well favored, and there is little further to do to comply with the requirements of this item; otherwise there is involved the construction of massive piers, so that the harbor can be entered in any state of the weather; and, if a natural channel of sufficient depth from the sea to the ship's berth does not already exist, the dredging of such a channel will also come under this head. But these questions in their broad philosophy are simple and comparatively unchanging, and what is done to-day in reference to them may be considered as suitable, if not for all time, at any rate for a comparatively long period.

(2) Having brought our ship into quiet waters, we must give her a berth. Here if nature provides a large river or sea inlet with a small rise of tide, we have need for nothing but riverside berths, but where such advantages do not exist we must carve basins out of the solid land,

the purpose of which is to provide as much quay frontage with as little waste of area as possible. To distribute the freight to the various final destinations, and per contra to collect it from the inland shipping center for the ship, good railway communication is a primary necessity, hence:

(3) Close to and parallel with the ship when lying at her berth is required a transshipment shed of one or more stories, provided with labor-saving devices for rapidly handling the cargo, and with (4) railway tracks in the rear, and in some cases in the front also, connecting directly with the (5) small yards, to facilitate the rapid interchange of empty and loaded cars, and with (6) the main marshalling, dispatching and receiving yard by tracks which are free from interruption caused either by the crossing of railway tracks or highways.

In what respects do British harbors fail to comply with these features? Chiefly, as before mentioned, in the poor railway arrangements, but also in the antiquated arrangements in general, due to the ultra permanent method of construction which has provided structures impossible of change without demolition, an operation costly in itself, involving the entire loss of the first cost of construction, and necessitating the closing down of the dock for long periods of time.

FIG. 13. LOCATION OF THE STEEL ARCH BRIDGE OVER CROOKED RIVER; OREGON TRUNK RY.

(The bridge will have a span of 350 ft. and a height of 350 ft. above the water.)

It is often the proud boast of an English corporation that their docks are so solidly constructed as to be indefinitely permanent. The author respectfully suggests that such an ideal has now been proven a false one. Nothing is more certain than that the methods of transportation both by sea and land will be vastly different thirty years hence from what they are to-day. What purpose can there be, then, in making the structures to be used so permanent that they can endure forever? Should not the ideal be rather to make structures sufficiently strong and durable to answer their immediate purpose, always keeping in mind that they will have to be deepened, widened, or rebuilt in, say, thirty years' time? But this can only apply to future extensions. What is to be done with the existing condition? No wholesale improvement can be effected, but rather piecemeal; chiefly at the lines of improved railway communication, and improved transit sheds with labor-saving devices for facilitating the transference of cargo between ship, shed and railway cars. With regard to extensions it is suggested that these take the form of the fuller development of natural resources rather than the construction of large artificial areas of water; which idea may be illustrated by a reference to the river Humber, where greater advantage might be taken of the opportunity to construct riverside berths, which are as efficient for practical purposes as deep inland docks and much cheaper to construct.

Above all, the problem should be studied in the same scientific manner as your society is advocating in the case of cities. Each port must be studied separately, its history and development, the sources, destination and nature of the cargo handled, the ships that frequent it, the conditions governing the railway approach, its geographical position and relation to foreign countries, other harbors and the inland cities; the cost of every operation involved in the working of the port from the time the pilot boards the ship at the harbor mouth to the moment when the train, loaded with the ship's cargo for the inland towns, leaves the main yard. Such costs should include the detailed cost of all operations, with standing supervision and capital charges added thereto, the results obtained from one port compared with those of another, and on the best data available of the conditions in other countries, a comparison made between conditions with us and those abroad. The author confidently predicts as a result of such study the discovery of methods of improved efficiency and economy which are to-day undreamed of, and which will repay a hundredfold the cost of such investigation.

Nothing strikes the intelligent visitor to our various harbors more than the divergency displayed in the design where conditions are not unlike. For instance, with a similar class of business to handle, Liverpool has one story sheds, and Manchester sheds with several stories; Liverpool has her sheds close to the quay edge with cranes on the roof; Manchester in her recent sheds has tracks between shed and quay edge, on which run high-legged cranes; in Great Britain, generally, the shed floor runs up from track level at the side of the shed nearest the ship to about 3 ft. 6 ins. above track, that is, to the level of the floor of the wagon at the side furthest away from the ship, or sometimes it is almost entirely at rail level, whereas in Germany, and in America, in otherwise very similar conditions, the shed floor is uniformly about 3 ft. 6 ins. above the track, there being a kind of platform outside the shed doors on both sides of the shed. Again, some ports still prefer the square-shaped dock, while others, catering for a similar trade, are using a modified form of the pier construction, and so on.

It is impossible, of course, to have anything like uniformity in harbor practice, owing to the different conditions that prevail in the different ports, but there is an absence in harbor practice in Great Britain of adequate uniformity of ideas such as exist to some extent in British railway practice; and this is all the more striking when one remembers that the ship is the common factor in all harbors, and that, speaking in general terms, any ship may go to any harbor, and any port must be prepared to receive any ship.

All this involves the changing of the local jealousy between our various ports, which at present leads to that baser form of competition exemplified in the secrecy with which the practice in one is kept from the ken of another, into the healthy rivalry which leads to the endeavor to outstrip each other by open methods of increased efficiency. Perhaps no sensible person who possesses to any reasonable degree the faculty of looking at things from an impartial point of view would dispute that, given an intelligent, keen patriotic and forceful public opinion and a plentiful supply of the right kind of official, the nationalization of our harbors and railways of Great Britain would be a most desirable object of attainment, but how far these conditions can be fulfilled to-day may be questioned.

In the meantime, the author suggests a compromise, namely, that the management of the harbors be left as they are, but an advisory body of men of the highest standing be appointed by the Government whose business it shall be to study the question from every point of view and watch and advise the various authorities, a body without power to enforce suggestions, but with power to enforce the supply of all information required by them. The result of such study would be made public for the use of all, and there would be no information or knowledge gained by one port that would not be placed at the disposal of all.

It must not be lost sight of that our ports are national assets and of national interest. Their success and efficiency is of vital moment in a greater or lesser degree to every individual in the nation. Nevertheless, the interest of the ordinary citizen cannot be compared with that of the merchant whose merchandise is shipped through the ports, of the ship owners whose ships use them, and of the railway companies to whom they are terminals. Hence it would be natural to suppose that corporate bodies representing these interests such as exist to-day could be expected to wisely manage the affairs of the ports in the interests of themselves, as much as in those of the nation.

On the whole these bodies have done well, but that something has been wanting is evident from the fact that no serious or official attempt has ever been made by them as a whole or by their officials to get together and discuss the question in its broader outlook in the way the author suggests should be done by a government commission. In case it should be said that such discussion is outside the province of the officials of our harbor trusts, the author, while pointing out that this would be an argument in favor of his scheme, would refer his opponent to a most efficient and successful society of this kind, namely, the American Railway Engineering and Permanent Way Association, a society composed of the leading engineers of the railways of the United States and Canada, who have voluntarily bound themselves together for the purpose of investigating the American railway problem in a very similar manner to that which the author now advocates for British harbors. The result of their efforts has already proved of the highest value, and promises still more for the future. But how much more could be accomplished by a public commission, as suggested above!

The author begs in conclusion to present this suggestion to the Society in the hope that if it seems to them likely to bring forth good results, they will use their efforts to induce the Government to give the question their fullest consideration.

THE PROFIT SHARING PLAN of the Boston Consolidated Gas Co., which was originated in 1906, is reported to have caused the apportionment last month of $47,314 among 584 employees. Of this number 439 were also holders of preferred stock in which security the above sum was distributed.

The Carnegie Swimming Pool at Yale University.

By C. S. FARNHAM.*

The Carnegie swimming pool which has recently been completed at Yale University is located in a substantial brick building of special design adjacent to the present gymnasium. The

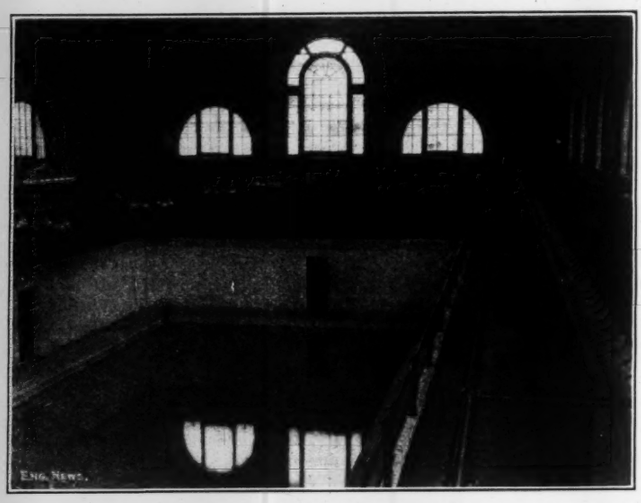

FIG. 1. VIEW OF THE INTERIOR OF THE NEW CARNEGIE SWIMMING POOL, YALE UNIVERSITY.

pool itself is a rectangular reinforced-concrete tank 75 ft. in length by 30 ft. in width with a capacity of 150,000 gals. The bottom is on a uniform slope giving a variable water depth of 10 ft. at the drain to 5½ ft. at the shallowest point. Water at a temperature of about 75° F. enters at one end and overflows into gutters which run the full length of the pool on both sides. The crest of these overflows is 9 ins. below the level of the tiled walk which entirely surrounds the pool. A constant inflow of fresh water is maintained during hours when the tank is in use, about 10,000 gals. being pumped daily.

The pool bottom rests directly upon compact sand and is reinforced with ¾-in. square bars spaced 12 ins. c. to c. in both directions with every third bar bent upward and extending to the top in the side and end walls. The walls are further reinforced by horizontal bars of the same size, spaced 12 ins. apart.

Concrete for the pool is a 1:2:4 mixture, Portland cement being used and run of crusher trap rock between the limits of ¼-in and 1-in. Floors and foundation footings are composed of similar materials with a 1:2½:5 mixture.

The specifications provided that the placing of concrete should be as nearly continuous as possible when once begun and that before placing the tile lining the work should be tested for water tightness by filling the pool with water and allowing it to stand for twelve hours without the water surface falling more than 1 in. After the concrete had been in place for about one month the tank was partially filled and the leakage found to be in excess of the requirement. The water was drawn off and the interior surfaces treated with a ½-in. coat of Portland cement mixed with "Hydratite." When this coating had hardened for a period of two months the tank was again filled and allowed to stand for 24 hours, during which time the water level fell about ⅜-in., no allowance being made for evaporation. The water was then drawn off and the tile finish put in position. This tile finish covers the entire inner surface of the pool and the floor of the surrounding walk, including the overflow gutters, and is carried up the side walls, facing the pool as far as the level of the gallery floor. The tiles are white with borders and game lines of blue tile which add materially to the appearance of the pool. The walks slope away from the pool to a gutter at the base of the wall so that dust on the walks or walls is not carried into the pool by water which happens to splash upon them.

The pool occupies the center of its enclosing building which is of brick, 64 × 120 ft. in plan, affording sufficient space to accommodate the various toilet, locker and Turkish bath rooms which open upon the walk surrounding the pool. This walk is 10 ft. in width on one end and 5 ft. wide at all other points. The space occupied by the pool and surrounding walk is open to the roof and is lighted in the day time by large arched windows on all four sides of the gallery floor and at night by incandescent clusters suspended from the roof trusses.

The second floor is arranged as a spectators' gallery with a seating capacity of about 500, the seats being in ampitheater form. The gallery is supported on Guastavino tile arches, as shown in Fig. 2, carried on cross beams between inner and outer brick walls. The gallery steps and passages are built up also of large flat tile covered with a wearing surface of cement mortar. Tile 6 × 15 × 1-in. in size were used in the arches laid in three layers, giving a total thickness of about 5 ins. Access to the gallery is by means of two stairways at the easterly end of the building and also through a covered passageway from the second floor of the adjacent gymnasium. The roof is of copper on yellow pine sheathing supported by I-beam purlins on steel trusses spaced 15 ft. c. to c.

All pipes are located in a concrete walled trench constructed for that purpose on three sides of the pool below the level of the first floor and adjacent to the pool walls. This trench connects with the mechanical plant in the adjoining gymnasium. In order to have the main drain pipe and its valves accessible they are placed in a concrete pit below the level of the pipe-trench floor. Leakage through the pool bottom at the drain pipe is prevented by means of a sheet of lead placed in the body of the concrete with the drain pipe passing through a hole in its center and having the edges of the hole turned up and brought to a watertight joint with the pipe surface by means of a bolted clamp. The diameter of the drain pipe is 8 ins. and of the supply pipe 4 ins.

On the first floor are numerous hose connections for cleaning walls and floors. Several exhaust connections are also provided so that any dirt floating on the surface of the pool may be withdrawn without having to drain the pool by reaching the hose nozzle out on a pole. Once a week the pool is drained and the sides and bottom thoroughly scrubbed. Water supply for the pool is derived from driven wells in the gymnasium yard.

Plans were prepared by Howell & Stokes, architects, New York, and the pool constructed by Sperry & Treat, New Haven, Conn., under the supervision of L. W. Robinson. The cost of pool and building complete was about $50,000.

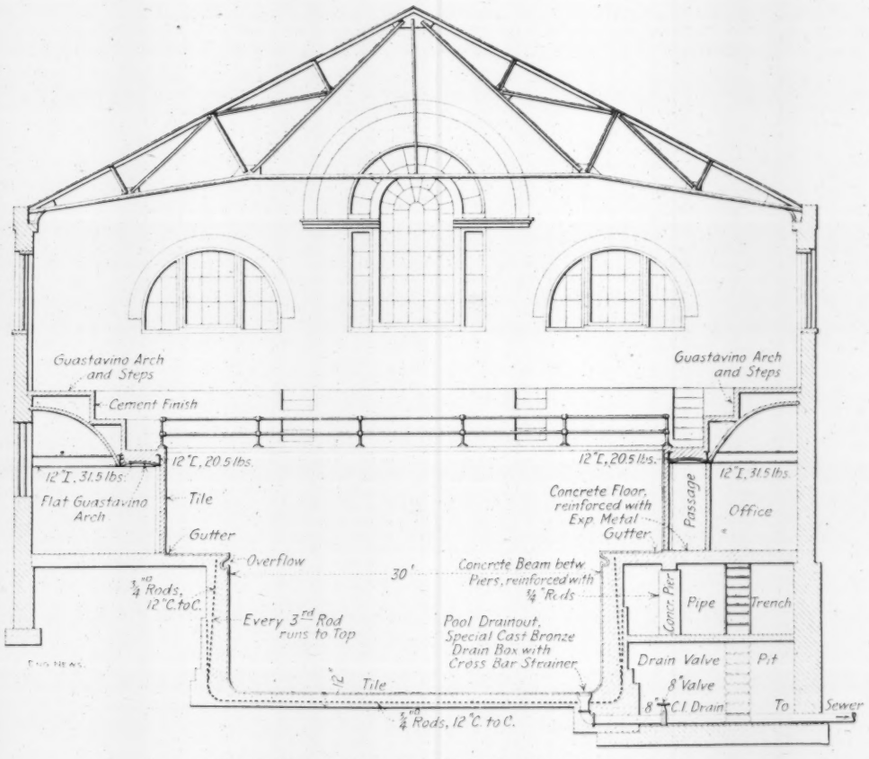

FIG. 2. LONGITUDINAL SECTION THROUGH POOL.

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THE RIGHT TO BUY ANY STREET RAILWAY system in San Francisco is provided for in an amendment to the city charter, drawn by the Charter Revision Convention of that city.

RAILWAY PLANTATIONS which have been established by the Cape Government Railways, of South Africa, for the supply of timber for ties now aggregate 6,553 acres. Unfortunately, the government does not make consistent or continual appropriations for the work. The Chief Conservator of Forests, in his annual report, states the reduction of expenditure to a minimum is not economical, as it retards extension work, and the plantations become consequently sample patches of varying ages from which no great sustained revenue can be expected ultimately, as would be the case if large areas were forested or planted at one time.

Field Assay of Water.*

By R. B. DOLE.†

In Engineering News for June 8, 1905, an article by Mr. Marshall O. Leighton discussed the economic possibilities of making partial approximate assays of natural waters, and described methods for performing some tests in the field by use of solid reagents and apparatus that can be carried in a small hand-case or in a knapsack.

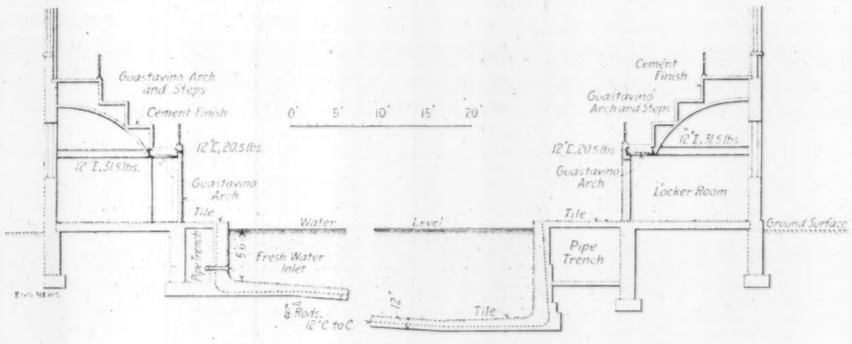

FIG. 3. TRANSVERSE SECTION THROUGH CARNEGIE POOL.

More detailed discussion of the tests has since been published by the same author.‡

Since the adoption of these procedures they have been used by Geological Survey parties in all sections of the United States in the examination of waters for geologic and industrial reconnaissance, more than 3,000 assays having been made during six field seasons. The results have been more or less reliable, as may be expected, according to the skill of the observers and the care with which the tests were carried out. As stated in the original article by Mr. Leighton, it has not been proposed to displace analysis of water in the laboratory by field assays, but to put into the hands of engineers, chemists, geologists, and other scientific explorers one more set of implements by use of which more ground can be covered with a given expenditure of money. Yet in spite of this avowed object many people have expected the field assay methods to yield results that may be compared with those of the laboratory in regard to accuracy and availability, and naturally they have been disappointed. The intention of the present article is to show the uses and the limitations of the methods in order that the profession may know to what extent they can be applied. For making practical comparison, 52 waters that had been analyzed in the laboratory were tested by the field methods. The tests for iron were made by Mr. Herman Stabler; the others were made by the writer. The results of the field assays and the corresponding laboratory determinations are given in the accompanying table side by side so that direct comparison can be made. The waters range in total solids from 25 to 5,200 parts per million and they represent the common kinds of surface and underground waters in the United States.

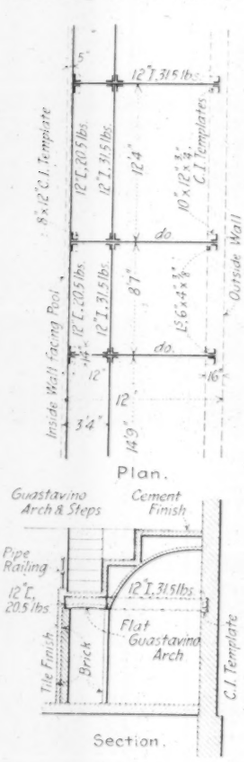

Fig. 4. Details of Gallery Support, Carnegie Pool, Yale University.

BICARBONATES.—The estimates of bicarbonates in the laboratory were made by titrating measured amounts of water with N/50 sulphuric acid in the presence of methyl orange indicator. The field tests were done in reverse manner; a proper number of tablets of sodium acid sulphate were dissolved in a small amount of the water to be assayed, methyl orange was added and then water until an alkaline endpoint was reached, after which the volume of liquid was measured. This is the regular field procedure except that the amount of water is less than that recommended by Mr. Leighton, being between 50 and 90 c. c. on account of the limited capacity of the porcelain mortar in which the titrations were performed. One of the tablets used in the tests is equivalent to 2.49 milligrams HCO_3. The parts per million of bicarbonates (HCO_3) in a water can readily be computed from the amount of water, the number of tablets, and the value of one tablet in milligrams of HCO_3.

The percentages of error of four determinations in the accompanying table are not significant because the bicarbonates are less than 20 parts; four other determinations are obviously incorrect, having errors greater than 20 parts. If these eight are omitted from consideration, the average error of the field tests is 6.2 parts per million, or 3.5%, with waters containing 100 to 350 parts per million of bicarbonates; the errors range from 0 to 9% and are equally divided between positive and negative. Further computation gives additional proof that the error is not a constant one, due to error in the value of the tablets or to the change in shade of the indicator, but that it is variable and is caused probably by error in measuring the water. The average error of 3.5% corresponds to 2.1 c. c. of water, which is not an unreasonably large variation, because the liquid is poured from a mortar containing a large pestle into a cylinder 1 in. in diameter graduated no finer than cubic centimeters. This method of titration gives results more nearly accurate than those from titrating 50 c. c. of water with tablets and quarter tablets, for it is feasible to cut a tablet into no smaller divisions than quarters, and one-quarter tablet with 50 c. c. of water is equivalent to 12.5 parts per million of HCO_3; therefore titration with quarter tablets to an acid endpoint is accurate only within 12.5 parts, whereas the reverse titration is accurate within 6.2 parts. Most waters do not contain normal carbonates (CO_3) and a qualitative test suffices to show their absence; but if it is necessary to make the quantitative determination it may be performed on a separate portion of water in the presence of phenolphthalein and the bicarbonate figure may be corrected in accordance with the result.

CHLORIDES.—In the laboratory tests chlorides less than 100 parts per million were estimated by titrating 100 to 250 c. c. of the water concentrated to 25 c. c. with a solution of silver nitrate 1 c. c. of which was equivalent to 0.5 milligram of chlorine; chlorides greater than 100 parts were estimated by precipitating and weighing the chlorides as silver chloride. In the field tests Mr. Leighton's method of titrating 50 c. c. of water with tablets and quarter tablets of silver nitrate was used. For low chlorides tablets equivalent to about one milligram of

COMPARISON OF LABORATORY TESTS WITH FIELD ASSAYS.

Chlorides (Cl).		Combined carbonic acid as bicarbonates (HCO_3).		Sulphates (SO_4).		Iron (Fe).		
							Field method—	
Laboratory method.	Field method.	Laboratory method.	Field method.	Laboratory method.	Field method.	Laboratory method.	A.	B.
20	24	174	169	2.5	5	...	...	...
2.4	4	13	13	1.7	tr	...	...	...
18	24	54	44	1.8	...	2.1	...	1.8
2.3	4	115	108	5.7	7	...	...	...
2.4	4	132	124	1.0	tr	...	...	...
158	160	160	156	56	52	...	...	...
7.3	14	11	12	8.3	tr	...	...	...
32	34	10	16	10	...	1.0	...	.0
2.5	9	138	125	3.3	5	...	...	...
6.5	9	153	142	3.9	5	...	...	...
4.9	9	178	166	2.8	tr	...	...	...
6.3	9	161	166	2.3	tr	...	...	...
193	190	158	158	344	406	...	...	...
9.2	14	131	129	5.8	5	...	...	...
499	502	160	161	355	430	...	...	...
193	205	205	215	8.9	8	1.3	.0	1.0
6.5	9	139	133	21	20	...	...	...
7.7	9	219	186	44	50	...	...	...
13	19	191	166	2.2	tr	...	...	...
5.4	9	113	119	2.3	5	.49	.0	.0
52	59	359	348	3.4	6	...	...	...
29	34	220	231	18	20	...	...	...
253	251	140	136	40	36	...	...	...
77	79	320	290	141	164	...	...	...
94	94	18	21	58	56	...	...	...
49	54	172	166	594	460	...	...	...
226	221	195	195	45	43	1.9	2.2	1.8
71	74	215	215	198	215	...	...	...
408	404	155	160	82	88	...	...	...
3.9	4	224	207	8.9	10	...	...	...
4.2	9	164	166	3.8	tr	...	...	...
8.3	14	210	215	8.1	7	...	...	...
30	34	163	159	149	150	...	...	...
32	39	288	282	15	15	1.4	.8	1.0
18	24	255	262	286	256	...	...	...
26	29	191	180	126	136	...	...	...
13	19	162	161	178	186	...	...	...
541	524	152	156	148	168	...	...	...
17	19	307	299	3.4	tr	.56	.2	.2
9.8	14	237	245	10	10	...	...	...
136	144	149	142	54	47	...	...	...
168	170	151	125	57	53	...	...	...
6.1	9	103	107	49	41	...	...	...
833	860	168	181	316	328	...	...	...
1,319	1,313	138	133	421	383	...	...	...
95	94	0	*	5.4	5	2.6	2.8	3.0
237	232	179	184	707	738	...	...	...
31	34	179	184	55	49	.44	.0	.0
88	94	106	107	3,241	2,870	...	...	...
703	709	175	178	1,670	1,720	...	...	...
40	44	38	38	2,582	1,910	2.4	tr	1.8
99	104	3.5	6	3,247	2,800	...	...	...

*100 c. c. water acid to methyl orange with one-quarter tablet of sodium acid sulphate.

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†Assistant Chemist, U. S. Geological Survey, Washington, D. C.

‡Water-Supply Paper No. 151, U. S. Geological Survey, obtainable from the Superintendent of Public Documents, Washington, D. C., for 10 cents, payable in advance.

chlorine were employed, and as one-quarter tablet in 50 c. c. of water is equivalent to 5 parts per million of chlorine, the field results may vary from the true values 5 parts, a difference that may be equivalent to 100% error. Chlorides actually between 2.3 and 7.7 parts were estimated as 4 or 9 parts; but as this method was never proposed for the estimation of normal chlorines such discrepancies offer little practical disadvantage, for it is as useful in geologic or industrial reconnaissance to know that a water contains less than 9 parts of chlorine as to know that it contains, for instance, exactly 5.4 parts. Field estimates of low chlorides should be made with 100 instead of 50 c. c. of water whenever practicable, as the increased amount of water gives additional accuracy. Tablets equivalent to 0.25 milligram and 0.50 milligram of chlorine as well as stronger ones have been tried, but the weaker tablets offer no particular advantage. One-quarter tablet of one milligram strength is equivalent to 0.25 milligram of chlorine like a tablet of the weakest strength, and moderate care in cutting a tablet into quarters gives pieces that vary in equivalent not more than 0.05 milligram of chlorine.

Of the 52 waters 22 contain more than 50 parts of chlorides. The average error of these 22 tests is 6 parts, or 3.2%, and the errors are almost evenly divided between positive and negative. Tablets equivalent to about 10 milligrams of chlorine as well as weaker ones were used in estimating high chlorides. Though none of the reported figures is an average, several estimates of chlorine were made on the strong waters with tablets of different strength and with tablets manufactured at different times and the results checked satisfactorily with each other. If the chromate indicator is added at the beginning of the titration of waters exceeding 400 or 500 parts of chlorides, an excess of silver nitrate may be added because the large flocculent particles of silver chloride formed during solution of the tablets become stained with silver chromate that is decomposed with difficulty. It is better, therefore, to make first a rough estimation of the chlorides and then to repeat the determination, the indicator in the latter test being added near the end of the titration. All the tablets except one or two may be ground with a small quantity of the water, then the remainder of the measured portion of water may be put in, and the titration completed in the usual manner. This modification involves little extra work and increases the accuracy of the results.

SULPHATES.—Sulphates were determined in the laboratory by the regular gravimetric method in 250 or 500 c. c. of water. In the field method only enough hydrochloric acid (1—1) was dropped into about 100 c. c. of water to make it slightly acid to methyl orange; then about one gram of coarsely pulverized barium chloride was added and the mixture was shaken about ten minutes, or longer if the precipitant was not entirely dissolved, after which the turbidity of the liquid was measured by means of the regular form of candle turbidimeter in a shaded corner of the laboratory during the daytime. The solution was kept constantly and thoroughly agitated while three readings were made. A standardization table gives the amount of sulphates corresponding to the average of the three readings. This differs from Mr. Leighton's procedure in that the water is made only slightly acid instead of strongly acid and the mixture is shaken constantly instead of being allowed to stand with occasional shakings. Probably more accurate readings could have been made in an absolutely dark room. The pink coloration by methyl orange makes no difference whatever in the reading. If care is exercised to add a minimum of acid and to agitate the liquid constantly in order to prevent concentration of barium chloride at the bottom of the tube during precipitation and to prevent agglomeration after precipitation, the crystals of barium sulphate are very small and fairly regular in size and the turbidity of the solution is more nearly constant for a given content of sulphates. This is a very important consideration and the one on which the success of the estimation rests. The glass graduate used with the regular turbidimeter is 24 centimeters long, permitting the reading of turbidities corresponding to sulphates between 30 and 600 parts per million. Less than 30 parts of sulphates, therefore, cannot be determined by the turbidimeter, and in waters below that concentration the sulphates were estimated by comparison of the turbidity with that produced in waters containing known amounts of sodium sulphate treated with acid and barium chloride. Such standards cannot be carried in the field, of course, but a skilled observer can remember their appearance well enough to estimate sulphates below 30 parts certainly within 50%. Waters containing more than 600 parts of sulphates were diluted to a convenient strength before precipitation with one of the waters containing only a trace of sulphates, though a water carrying 10 to 20 parts of sulphates would have served as well as a diluent. The best range for readings is between 2.5 and 12 c. c., corresponding respectively to 265 and 56 parts of SO_4, and it is better to dilute so that the readings will be between those limits.

Twenty-seven of the 52 waters contained more than 30 parts of SO_4 and the average error of determination for those is 10%; sulphates may be estimated by this method within 10% if the results of three or four tests are averaged. For turbidimeter readings between 2.0 and 19 cm. the average error is 8.5%; for readings less than 2.0 cm. and for sulphates greater than 600 parts per million the errors of single estimates are much greater, averaging 14.4% for the nine reported here. Individual determinations of high sulphates would be liable to great error because a difference of one cubic centimeter in measuring the water during dilution or a difference of one millimeter in measuring the turbidity is proportionately magnified in the result.

IRON.—In the laboratory the iron in the residue from 500 c. c. of water was removed as ferric hydrate and redissolved; then the amount of iron in this solution, or in an aliquot part of it, was estimated by the usual colorimetric method, the reddish hue developed by potassium sulphocyanide being compared directly or indirectly with that developed in standard solutions of ferric chloride. According to the directions for the field test 45 c. c. of water and 2 c. c. of concentrated nitric acid are thoroughly mixed and allowed to stand five minutes; 3 c. c. of a 2% solution of potassium sulphocyanide are then added. After the solution has stood ten minutes, the red color of it is compared with that of standard celluloid disks, the solution being poured into a glass-capped aluminum tube for that purpose. It was quickly found in practice that the compounds producing the red color are progressively decomposed by free nitric acid, and therefore the comparison of colors has been made immediately after adding the potassium sulphocyanide instead of after an interval of ten minutes. Column "A" under "Iron" in the accompanying table gives the results of tests for iron by the regular field method and column "B" the results of tests made in the same way except that the mixture of water and nitric acid was allowed to stand for one hour before addition of potassium sulphocyanide. Both series of assays were made by Mr. Herman Stabler. It is evident from comparison of these figures with those of the laboratory analyses that the iron in nearly all the samples was not completely oxidized by nitric acid in the cold and that more complete oxidation occurred if the mixture of acid and water was allowed to stand for a considerable length of time. The degree of change into the ferric form depends on the composition of the water and the chemical condition of the iron. Apparently much organic matter retards the change more than anything else in natural waters. The differences between the laboratory and field figures are not due to error in standardization of the celluloid disks, because these were tested very carefully both before and after the experiments, and the same disks were used also in making the regular laboratory estimates of iron. Indeed a set of disks will retain their colors for several years if they are protected at all times from contact with acid or acid fumes and from the sunlight when they are not in use. Though the results of the iron comparisons are fairly satisfactory it is evident that oxidation of the iron should be continued for a longer time and that this action should be accelerated by heat whenever it is possible to do so.

SCALE-FORMING CONSTITUENTS.—If figures representing the amounts of calcium and magnesium in water could be obtained by field tests estimates of the approximate content of scale-forming ingredients could readily be computed. The turbidimetric method of estimating calcium proposed by Mr. Leighton is subject to such great, but uncertain, errors under common working conditions that the results should not be numerically expressed. The procedure outlined by Mr. Charles Catlett* for estimating magnesium in limestones has not been adapted to water work, and consequently its availability in that line is unknown. The figure for total hardness obtained by titrating a measured portion of water with sodium oleate tablets can be considered an approximate value for scale-forming ingredients up to 100 parts per million. Figures for total hardness greater than 100 parts are usually too low because of the interference of calcium and magnesium soaps with the reactions. For very hard waters an estimate of the probable scale can be made from the figures for total hardness, sulphates, and bicarbonates. If the sulphates are computed to calcium sulphate and the bicarbonates to calcium carbonate and the two amounts added together, the sum represents the greatest amount of calcium and magnesium compounds that could be in the scale. An average between this sum and total hardness by the sodium oleate method represents more or less approximately the amount of scale-forming material in normal hard waters. The relation may be expressed thus:

$$S = 0.41\ HCO_3 + 0.71\ SO_4 + 0.50\ H.$$

In this formula S, HCO_3, SO_4, and H represent respectively the amounts in parts per million of scale, bicarbonates, sulphates, and total hardness. Theoretically, the difference between 0.50 H and (0.41 HCO_3 + 0.71 SO_4) should depend on the amount of alkaline bases in equilibrium with the bicarbonate and sulphate radicles, but practically this relation is affected by the inaccuracy of the determination of total hardness. Provision for suspended matter and iron could be made in the formula if desirable but suspended matter usually is removed from water before its use in boilers and the influence of iron would be less than the probable error of the computation; silica and aluminum may be disregarded for the same reason. If this approximate figure is considered in connection with the amount of chlorides and the possible presence of hydrogen sulphide as revealed by the odor or of free sulphuric or hydrochloric acids, comparative classification in respect to steaming qualities may be made accurately enough for reconnaissance work. This method of computation was successfully used in classifying 300 assays of waters that were made in Iowa and Indiana during a study of boiler-water conditions in those states. It is possible by this means to compare the quality of local waters and in preliminary work to discard without expensive and time-consuming laboratory analyses waters of excessive mineral content as well as to select for more careful consideration the waters that are most promising.

CONCLUSION.—From the results given here and from other practical experience it may be concluded that the assay tests for chlorides, sulphates, carbonates, and bicarbonates are as accurate as they need to be for preliminary work. The iron test is likely to give low results in many waters, and more time should be allowed for the oxidation of the iron. The test for total hardness, though laborious in hard waters, yields information valuable enough to make its performance worth while. The calcium test cannot be relied upon more than to indicate whether waters are high or low in calcium, and the results of

*Trans. Am. Inst. of Mining Engineers, Vol. 38, 1907, p. 705.

this test should not be expressed in figures. In reporting results no decimals should be given except in iron, where one decimal place may be reported. The assays should always be made by persons having some knowledge of chemistry and a thorough training in the technique of the tests as well as an appreciation of their limitations.

Determination of the Resultant Angle in Laying Out Combined Bends for Pipe Lines.

By C. A. JACKSON.*

In designing pipe lines, the condition often arises that both a horizontal and vertical deflection occur at the same point, in which case one bend can readily be made to give the resultant of the two angles. Many engineers avoid the use of these combined bends by placing a horizontal bend with a vertical bend following, or vice versa. This practice is not to be recommended, since the sum of the angles in the horizontal and vertical bends is usually about 1½ times as great as in a single bend combining the two angles, thus increasing the cost of the pipe,

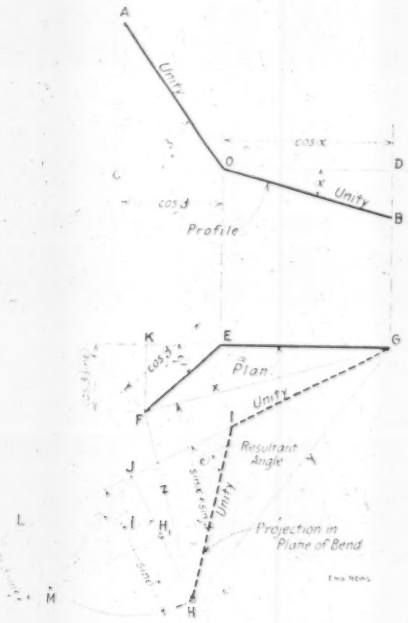


Fig. 1. Diagram for Graphic Determination of Design of Combined Pipe Bend to Replace a Vertical and a Horizontal Bend.

as well as the friction loss. The angle for the combined bend can be determined by either a graphical or analytical solution.

Graphical Method.

Where two angles are to be combined in the same bend the resultant angle in the plane of the bend can readily be found graphically by the following method.

In Fig. 1 let

α = angle of inclination from horizontal of one pipe line in profile.†

β = angle of inclination from horizontal of other pipe line in profile.

ϕ = horizontal deflection of bend.

δ = resultant angle in plane of bend.

λ = angle between plane of bend and horizontal center line of flange at B.

λ_1 = angle between plane of bend and horizontal center line of flange at A.

The lengths of lines $O\ A$ and $O\ B$ in profile are taken as unity for convenience in calculating.

First project the points A and B to the ground line and lay off $F\ E$ on the plan equal to $O\ C$ in profile, then $F\ E$ is the true horizontal projection of the line $O\ A$. In the same manner lay off $E\ G$ which is the horizontal projection of the line $O\ B$. Now connect the points $F\ G$ by means of the line X, which is the horizontal projection of a line connecting the points F and G, and is therefore the base of a triangle, the perpendicular of which is the true height of the point A above $B = D\ B + A\ C = Z$, and the hypotenuse the true distance between A and B which is denoted by Y. Having found the true distance between these points, we can construct the triangle $G\ H\ I$, of which one side has the length Y and each of the other two sides is unity. The triangle is now constructed and the resultant angle δ found. The lines GI and HI represent the extreme tangents to the arc of the bend when it is lying flat on its side.

Locations of Flange Center Line.

In order to determine the position of the horizontal center line of the end flange at B when the elbow is in its natural position, let us imagine ourselves looking along the line from G to I, which corresponds with $B\ O$ in the profile. The bend is now revolved about the axis $G\ I$ until the point H is a distance $F\ K$ from a vertical plane passing through $G\ I$. This is found by laying off from the line $G\ I$ produced, a distance $J\ H_1 = F\ K$. Through H_1 draw a line $H_1\ M$ parallel to $G\ L$, then with a radius $J\ H$ draw an arc cutting this line at M. The angle $H\ J\ M$ thus formed is the angle λ between the plane of the elbow and the horizontal center line of the flange on lower end when elbow is in the desired position. The bend must be revolved toward the right (when looking from G to I) to bring it into position, so the angle λ will be laid off to the left of a flange center line in the plane of the bend, that is, to the left of a center line which is horizontal when the elbow is lying flat. Having found the horizontal center line for the bend when in position, the holes for bolts or rivets may be laid out to straddle the center line or otherwise as desired.

Analytical Method.

The analytical method is much more accurate than the graphical and is as follows:

TO FIND δ.—In Fig. 1,

$$X^2 = \cos^2 \alpha + \cos^2 \beta + 2 \cos \alpha \cos \beta \cos \phi$$

and

$$Y^2 = X^2 + Z^2$$

then substituting the values of X^2 and Z^2

$$Y^2 = \cos^2 \alpha + \cos^2 \beta + 2 \cos \alpha \cos \beta \cos \phi + (\sin \alpha + \sin \beta)^2.$$

Since

Y = true distance between A and B,

we have

$$Y^2 = (1 + \cos \delta)^2 + \sin^2 \delta$$
$$= 2 + 2 \cos \delta = 2\ (1 + \cos \delta),$$

therefore, equating the values of Y^2,

$$2\ (1 + \cos \delta) = \cos^2 \alpha + \cos^2 \beta + 2 \cos \alpha \cos \beta \cos \phi + \sin^2 \alpha + 2 \sin \alpha \sin \beta + \sin^2 \beta,$$

from which

$$2\ (1 + \cos \delta) = 2 + 2 \cos \alpha \cos \beta \cos \phi + 2 \sin \alpha \sin \beta,$$

and

$$\cos \delta = \cos \alpha \cos \beta \cos \phi + \sin \alpha \sin \beta \ldots\ldots (1).$$

TO FIND λ.—

$$M\ L = \cos \beta \sin \phi,$$
$$H\ J = \sin \delta.$$

Then

$$\sin (90° - \lambda) = \frac{\cos \beta \sin \phi}{\sin \delta}.$$

And

$$\cos \lambda = \frac{\cos \beta \sin \phi}{\sin \delta} \ldots\ldots (2).$$

Similarly for the flange at H, when looking toward I,

$$\cos \lambda_1 = \frac{\cos \alpha \sin \phi}{\sin \delta} \ldots\ldots (3)$$

If a horizontal deflection only is required, in a bend which is to be laid on a slope, then $\alpha = \beta$ and the formula for resultant angle in the plane of the elbow becomes

$$\cos \delta = \cos^2 \alpha \cos \phi + \sin^2 \alpha.$$

If either pipe line is horizontal, then either α or β is zero, the sin becomes zero and the last part of the formula disappears, leaving

$$\cos \delta = \cos \alpha \text{ (or } \beta) \cos \phi.$$

Example.

The following example will serve to illustrate the method of using the formula.

In Fig. 2 is shown a bend in profile with location of holes in flanges, in Fig. 3 a plan view showing horizontal deflection, and in Fig. 4 the resultant bend lying flat on its side. The following data are assumed for the bend:

$\alpha = 15°\ 0'$; $\beta = 56°\ 0'$; $\phi = 42°\ 0'$.

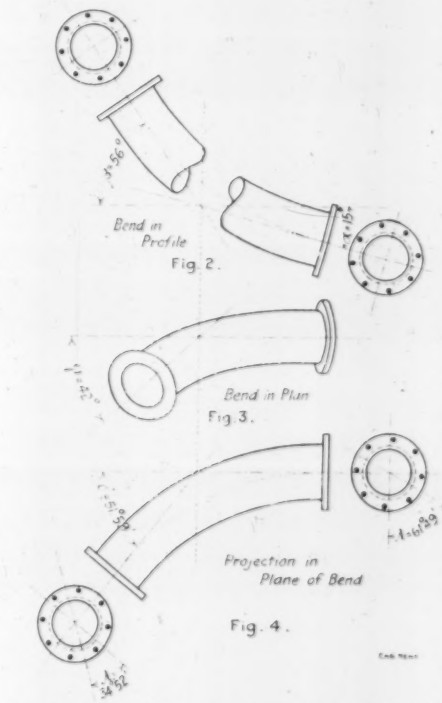
Then cos α = .96592; cos β = .55919; cos ϕ = .74314; and sin α = .25882; sin β = .82903.

Substituting in equation (1),

$$\cos \delta = \cos \alpha \cos \beta \cos \phi + \sin \alpha \sin \beta,$$
$$= .96592 \times .55919 \times .74314 + .25882 \times .82903,$$
$$= .40139 + .21457,$$
$$= .61596.$$

Then $\delta = 51°\ 59'$.

Let us suppose that this is a flanged bend and that the lower end is to be bolted to an existing fitting whose axis is inclined at an angle of 15°



Figs. 2, 3, 4. Profile and Projections of Combined Bend as Determined by the Diagram in Fig. 1.

from the horizontal and that the bolt holes in the flange are drilled to straddle the vertical center line.

Having found $\delta = 51°\ 59'$ and given $\phi = 42°\ 0'$ and $\beta = 56°\ 0'$, we have from equation (2)

$$\cos \lambda = \frac{\cos \beta \sin \phi}{\sin \delta} = \frac{.55919 \times .66913}{.78783},$$
$$= .4744,$$
and $\lambda = 61°\ 41'$.

Since the horizontal deflection of the bend is to the left and the vertical bend upward, the plane of the bend will be on the left and above the center line. The angle λ will therefore be laid out as shown in Fig. 4 on the left and below the center line of the bend when it is lying flat, so that it will be the horizontal center line of the flange when the bend is revolved upward into its natural position. The vertical center line of flange can now be drawn and the holes laid out to match the adjoining flange.

The upper end of the bend is laid out in the same manner except that we imagine ourselves looking along the line from H to I. The angle λ_1 is now found by formula (3).

$$\cos \lambda_1 = \frac{\cos \alpha \sin \phi}{\sin \delta} = \frac{.96592 \times .66913}{.78783} = .8204.$$

Then $\lambda_1 = 34°\ 52'$.

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†Profile is used throughout this article to mean projection on a vertical plane parallel to that pipe line of which the projection is taken. Thus in Fig. 1, A O and O B are vertical projections of the two pipe lines but are not projected on the same plane. Each projection is on a plane parallel to its corresponding pipe line.

When looking from the point A with the bend in its proper position the deflection of the bend will be to the right of $A\ O$ and above a plane passing through the horizontal center line of the flange and the line $A\ O$, hence angle λ_1 will be laid out as shown in Fig. 4, on the right and below the horizontal center line of the bend when same is lying flat. This will be the horizontal center line of flange when bend is in position, so the holes may be laid out to match the next piece of pipe. Fig. 2 shows these holes laid out to straddle the vertical center line, which is standard practice.

Remarks.

A careful application of the above method will save engineers and contractors many unnecessary bends in pipe lines as well as much lost time and extra expense in drilling holes in the field, since the usual practice where combined bends are used is to leave the holes for bolts or rivets to be drilled at the plant, where the appliances for doing such work are almost invariably very inadequate.

Where small angles occur in large pipe lines with riveted field joints, it is usually sufficient to have the resultant angle correct and use the standard location for rivet holes, as the bend cannot come more than one-half of one rivet space out of place, which amounts to practically nothing unless the resultant angle is more than 20°.

[The author's solution, as given above, departs somewhat from the conventional methods of descriptive geometry, possibly with some loss in convenience for the graphical solution. The conventional methods give a somewhat simpler and equally accurate diagram.

In Fig. 5, the two pipe lines ($O\ F$ and $O\ G$) are represented by their horizontal projections, $o\ f$ and $o\ g$, and their vertical projections, $o'\ f'$ and $o'\ g'$. The line $O\ G$ lies in the vertical plane and is therefore shown in its true length in the vertical projection, $o'\ g'$. The line $O\ F$ can be revolved into the vertical plane about a vertical line through O, when it will appear in its true length as shown at $o'\ A$, which is the same as the profile, $O\ A$, in Fig. 1.

The simplest solution for the true value, δ, of the angle between the lines $O\ F$ and $O\ G$ measured in the plane common to both (plane of the bend) is obtained by revolving the bend into the vertical plane about the line $G\ O$. The point F will revolve to position H, lying on a perpendicular to $g'\ o'$ produced, and will be at such a distance from o' that $o'\ H = o'\ A$. The angle $H\ o'\ g'$ can then be drawn in its true size and shape, giving at once the desired angle δ.

The solution for the angle λ can be obtained by taking a projection of the line $O\ F$ on a plane passing through F (in space) and perpendicular to the vertical plane and to the line $O\ G$. The vertical trace of this plane is the line $J\ f'$, drawn through f' and perpendicular to $g'\ o'$ produced. In order to show the projection on this plane, we revolve the plane about its trace $J\ f'$ until it coincides with the vertical plane. The point F will fall at M on a perpendicular erected to the line $J\ f'$ at f'. The distance $f'\ M$ will be the same as $K\ f$, shown in the horizontal projection. The line $G\ O$ will, of course, be projected on this plane to which it is perpendicular in the point J. The line $J\ M$ can now be drawn and the angle λ measured.

To find the value of the angle λ_1, we can take a projection of the combined bend on a plane at right angles to the line $O\ F$. For convenience this plane is passed through the point O. Its vertical trace is $O'\ T'$ at right angles to $O'\ f'$ and its horizontal trace $O\ T$ at right angles to $O\ f$. The projection on this plane of the line $O\ F$ will be the point O. To find the projection on this plane ($T\ O\ T'$) of the line $O\ G$ we have only to locate the projection on it of the point G.

Let this point, the projection of G on plane $T\ O\ T'$, be P. The horizontal projection of P will lie somewhere in the horizontal trace, $g\ U$, of a vertical plane through G perpendicular to plane $T\ O\ T'$. The vertical projection P will lie in the vertical trace $g'\ r'$ of a plane perpendicular to $T\ O\ T'$ and to the vertical plane.

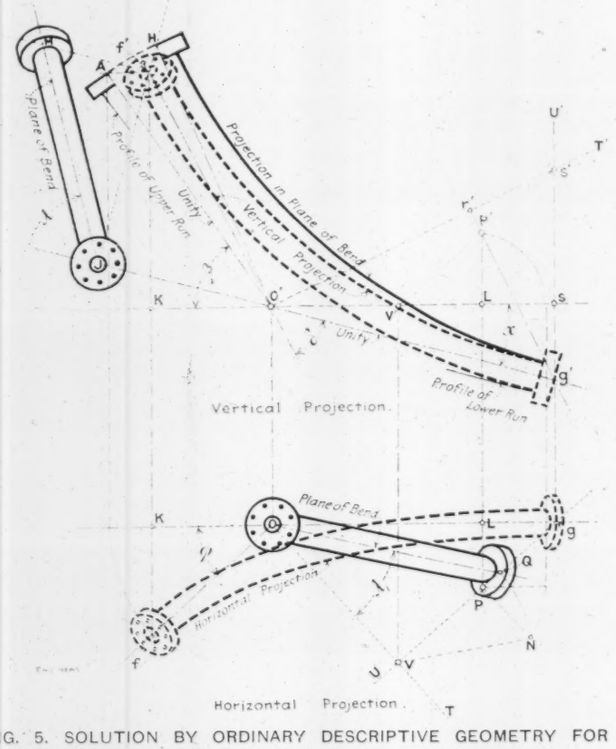

FIG. 5. SOLUTION BY ORDINARY DESCRIPTIVE GEOMETRY FOR THE DESIGN OF THE COMBINED PIPE BEND SHOWN IN FIGS. 2-4.

The point P lies, of course, in the line of intersection of the two planes $T\ O\ T'$ and $U\ G\ U'$, since it is contained in both these planes. This line of intersection is horizontally projected in the trace $g\ U$, and the point v, where $g\ U$ intersects $O\ T$, is in this line, and is vertically projected in the ground line, at v'. The point s', at the intersection of $g'\ U'$ and $O'\ T'$, is the vertical projection of another point in the line of intersection of planes $U\ G\ U'$ and $T\ O\ T'$. Therefore $v'\ s'$ is the vertical projection of this line of intersection, and the vertical projection of P is now found at p' where $v'\ s'$ and $g'\ r'$ intersect.

The plane $T\ O\ T'$ can now be revolved about its horizontal trace $O\ T$ until it coincides with the horizontal plane. The point P will fall at Q, on the line Ug, at a distance from line $O\ T$ of $v\ Q = v\ N$. The length $v\ N$ is the hypotenuse of a right triangle of which $v\ p$ is the base and $L\ p = p\ N$ the altitude. The line $Q\ O$ can now be drawn and the angle $Q\ O\ T$ is the desired angle λ_1.

This solution involves the drawing of fewer lines than that given by the author, except in the part relating to λ_1, and it gives an opportunity to sketch in the bend itself, as shown in Fig. 5, in such a way that no separate drawings are necessary for the workmen.—Ed.]

Depositing Concrete Under Water on the Slope Walls of the Lachine Canal.*

By HENRY R. LORDLY.†

Originally the slope walls of the Lachine Canal, near Montreal, were riprapped largely with the stone excavated from the work. Some of this stone, which was of the nature of a dark shale, disintegrated, and under the increased wave action, due to steam towage and steam-propelled vessels, large areas of the walls were destroyed. In 1898 it was decided to rebuild the damaged wall in heavy courses with crystalline grey limestone from the Caughnawaga quarries. The base of the new wall was about 3 ft. thick, and the course decreased 1 in. per ft. of slope. Above the water-line was a coping course, and on top of this a revetment of broken stone was placed, to take the wash of the steamers.

This work was carried on for a number of seasons during the period of unwatering, in the month of April. As there were upwards of seven miles of wall to rebuild, and the progress made by working only two or three weeks each year could not be otherwise than slow, it was seen that some other method must be adopted in order to hasten the protection of the banks.

In 1904 the author, who was then in charge of the work, was instructed to prepare plans for rebuilding the walls in a more expeditious manner.

The Superintending Engineer of the Quebec Canal Division, Mr. E. Marceau, approved of using concrete on the slope walls, and this material had already been very largely used in rebuilding the locks and the vertical walls at the entrance to the canal. By the use of concrete much skilled and expensive labor could be dispensed with; stonecutters were difficult to get and harder to hold, particularly in the early spring time.

The face of the slope wall is about 24 ft. (slope 1 to 1). It was first decided to use a belt of concrete, 8 to 12 ft. wide and 1 ft. thick.

This belt was to be placed in the middle section of the wall, leaving in any riprap below which was in good condition, and running the concrete all the way down in a column, 5 ft. wide, to a firm foundation, at points about 24 ft. centers. From the 16-ft. level, up, the ordinary limestone riprap, as originally designed, was to be used. With this plan of doing the work it seemed possible to provide for a considerable length of the concrete belt being placed rapidly, so as to permit the stonelayers to finish the work by the first of May, when the water was run into the canal, and also to save portions of the old riprap that were firm. The work was generally started by April 3 or 4, but usually it was difficult to get more than three good working weeks.

In the execution of this plan some difficulty was found in using mold boards for the face. They proved difficult to keep in place, and more expensive to handle than was anticipated. In some portions of the wall an attempt was made to use a stiffer concrete, about 1 ft. thick, laid on without any forms, but this proved too slow. About a quarter of a mile was done in three weeks, although the rocky bottom of this particular portion of the canal did not require as much concrete as would be called for in other sections.

The method outlined above gave a higher class of wall, and more of it, in a limited time. By it also the cost of labor was reduced, thus offsetting to some extent the extra cost for cement.

The wall on the south side of the canal, upper reach, was steadily getting worse, and on the north side a number of leaks were in evidence. The method of doing the work in the dry had proved too slow, and some more rapid system had to be devised.

It was then proposed that the walls should be laid entirely in concrete, except the revetment, and that the whole work should be done without unwatering the canal and during the period of navigation.

Under-water-concrete work had already been done in some minor cases on the canal, and one experience, that of the abutments of Black's Bridge, was taken as suggesting the possibility of successful subaqueous construction of the slope walls. In the spring of 1903, during the building of the north abutment of this bridge, just after the forms had been placed, the water in the river rose rapidly, until there was a depth of 23 ft. over the foundation. Time did not permit of waiting for the water to recede. At first a wooden chute was used and the concrete dropped through it, but after one corner of the forms had been filled, the box was discarded, and the concrete was dumped from barrows directly on the edge of the filled portion and allowed to flow forward at its own natural slope. The slow movement of the concrete was the best guarantee against washing out of the cement. The water was cold, and the set retarded sufficiently to aid the work in preventing injury to the placed concrete while the successive batches were dumped on the top of the sloping mass in situ. There was no current in the canal, but, on account of the rise and fall of the water in the river, a slight undulating move-

*Portion of a paper entitled "Subaqueous Concrete Work" read, March 17, 1910, before the Canadian Society of Civil Engineers.

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ment was experienced. This abutment, which had a width of from 14 to 8 ft., and a total length of 80 ft., was thus satisfactorily completed in time.

The face of the wall, when the forms were removed, was found smooth and in perfect condition.

In lining the prism walls below water with concrete a different problem arose. Navigation was to be maintained; the current in the canal of about one mile per hour and the wash of passing vessels had to be provided for.

The face of the wall is 24 ft., slope 1 to 1. The thickness of concrete required 18 ins., and, as forms would have to be used, there was a danger of the concrete clogging between the form and the projections of the old masonry wall, thus creating large voids. A method of preventing the clogging and forcing the concrete down in place had to be devised.

After some preliminary discussion, the contractors for the original work, Messrs. Haney, Miller, Quinlan & Robertson, came forward with an offer to do the work under the above conditions, and agreed to build the following plant: Six forms, 100 ft. by 24 ft. face; a mixing plant, with a ram and box that would carry the concrete down between the wall and the forms; a lifting scow; a diving plant, etc., etc. The plant was calculated to do 200 cu. yds. per day.

It was proposed to prepare the toe of the walls during the spring unwatering. The forms were to be floated to the work, during the period of navigation, placed by the aid of the lifting scow and divers, and heavily loaded at the bottom to remain in position.

Each form would be kept in place until the concrete was set sufficiently hard to permit of its removal, and would then be moved to the head of the line in order to continue the work.

The designing of the forms and plant was placed in care of Mr. A. T. Gibson, the chief assistant engineer for the contractors.

While the resultant pressure behind the forms would not be great, their large size, the flotation to be overcome, and the force of the wash from passing steamers was sufficient to make the problem of their design and retention in place a difficult one.

A special lifting scow for erecting and removing the forms was also required.

Requirements of the Design.

In designing the mixing and laying plant, which was to be on scows, some important points had to be considered.

1. The scows must be narrow and lay parallel (longitudinally) to the banks in order not to obstruct navigation.

2. The ram carrying the box with movable bottom to deposit the concrete required to be operated on a slope of 45°.

3. Its tendency to move with the wave undulations had to be overcome.

4. The ram had also to be so designed that it could be moved past any obstructions on the banks, electric current poles, telegraph poles, etc.

5. The operating machinery of the ram required to be under perfect control and but little agitation of the water behind the forms created by its action.

In addition to the above, a supply bin, an automatic hoist and measure, to feed the mixer, had to be designed to suit the requirements of the work. A diving outfit and lifting scow, anchors for the molds, etc., were also required.

It will be thus seen that the conditions were many and somewhat difficult to overcome.

Design of Plant.

FORMS.—The forms were constructed of heavy timber, each form being 100 x 22 ft., additional width being added at the top by placing longitudinal planks on the part out of the water.

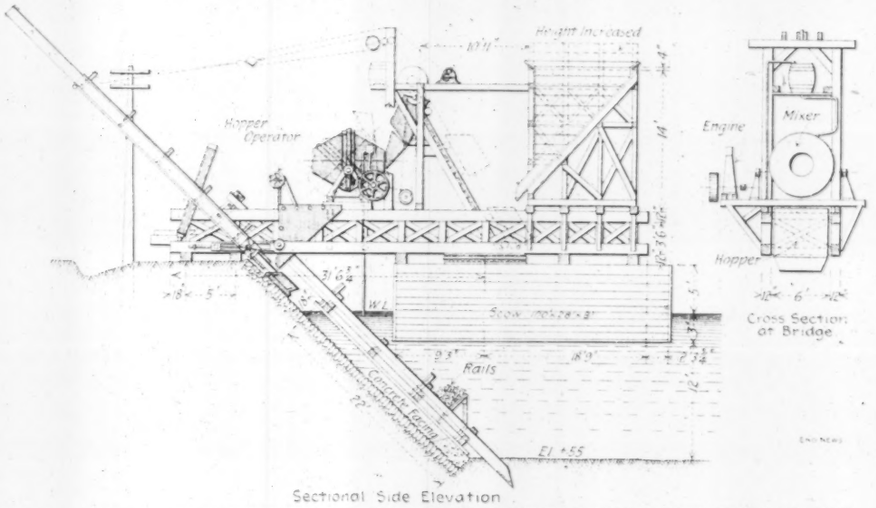

FIG. 1. GENERAL ARRANGEMENT OF THE CONCRETE LAYING PLANT USED IN THE SUBAQUEOUS DEPOSITING OF CONCRETE ON SLOPE WALLS OF THE LACHINE CANAL.

Fig. 3 gives a good idea of the method of construction and the details of the longitudinal trusses to give stiffness to the framework. The heavy timbers were British Columbia fir. A platform or cradle was provided about 5 ft. from the bottom of the mold to hold iron rails for ballast. The entire plan was carefully carried out, and, as will be seen later, the forms were perfectly successful and rigid enough to be kept in nearly perfect alinement.

MIXING AND DEPOSITING PLANT.—Fig. 1 gives the general arrangement and details of the mixing plant. The plant is shown in place and ready for operation. It will be noticed that the scow is a narrow one, and that the overhang platform carrying the mixer and receiver hopper is partly counterbalanced by the stone and sand bin. The bin had both a sand and stone compartment, the material being taken from the barges alongside by a clam operated by a stiff-leg derrick placed at the other end of the scow.

MEASURING CAR.—The measuring car, about 32 cu. ft. capacity, is shown in three positions, and its method of operation is well worth a careful examination.

After being fed by the chute while in its lowest position, the cement being placed in from the side by hand, the car ascends the double-rail track and turns completely upside down.

The intermediate position would show the rear wheels, first in the air, free of any rail, and next engaging the rail, which carries it while dumping. This apparatus, as designed by Mr. A. T. Gibson, was one of the most efficient parts of the plant.

The feed car dumped into the mixer hopper, and, after the materials were mixed, the concrete was dumped into a receiving hopper, from which the box on the ram was supplied.

This supply hopper held about three batches of concrete, and allowed the mixer to be run almost continuously without depending on the speed of the ram, which was at times likely to be irregular.

The face form is shown in place, in this sketch, with its loading ballast and lower layer of concrete in process of filling in. The ram is in its highest position, the box being ready to receive its supply, about 12 cu. ft. from the hopper.

It will be noted that the strain on the ram arm is taken by a wire cable, operated with block and tackle by means of a winch from the frame above the mixer. A part of the frame is omitted from the sketch in order to show the measuring car.

RAM AND GUIDE.—It will be remembered that one of the problems of this undertaking was to place the concrete between the old masonry wall and the forms for the concrete facing without clogging up the space near the top, and thus creating voids at the bottom of the wall. Had the thickness of the new wall been greater, or the surface of the old masonry wall, or the bank, been smoother, this difficulty would not have occurred. As a matter of fact, as results proved, there were places where the ram was not required.

Fig. 2 shows the details of the ram and guide. In most of the work the guide was maintained at an angle of 45°, but it could be adjusted to work nearer the vertical if required. The ram frame was made of timber, and the guide of 15-in. steel channels. The latter was carried in a gudgeon bearing attached to the inclined post support, which may be seen in Fig. 1.

The ram and box would drop by gravity, and was drawn back or controlled by a steel cable operated from the hoist.

OPERATION OF THE PLANT.—The entire plant was ready for work early in June, 1907. In April the canal was unwatered for a portion of the month and gangs of men put on to prepare the slope wall, on the south side, for the new facing. All the loose stones were removed and the toe of the wall made ready to receive the bottom of the mold. Photographs were taken of any sections presenting unusual irregularities, and all the necessary data provided as to the condition and slope of the bank.

PLACING THE FORMS.—The first section was started on the south bank, a few hundred feet above the Cote St. Paul Bridge, a location which, in so far as agitation of the water and limitation of working room were concerned, was the worst possible.

The forms were floated opposite the site, raised up by the slings with the lifting derrick, and lowered down in front of the bank. The diver then descended and checked the distance from the wall to the mold, guided the rail-

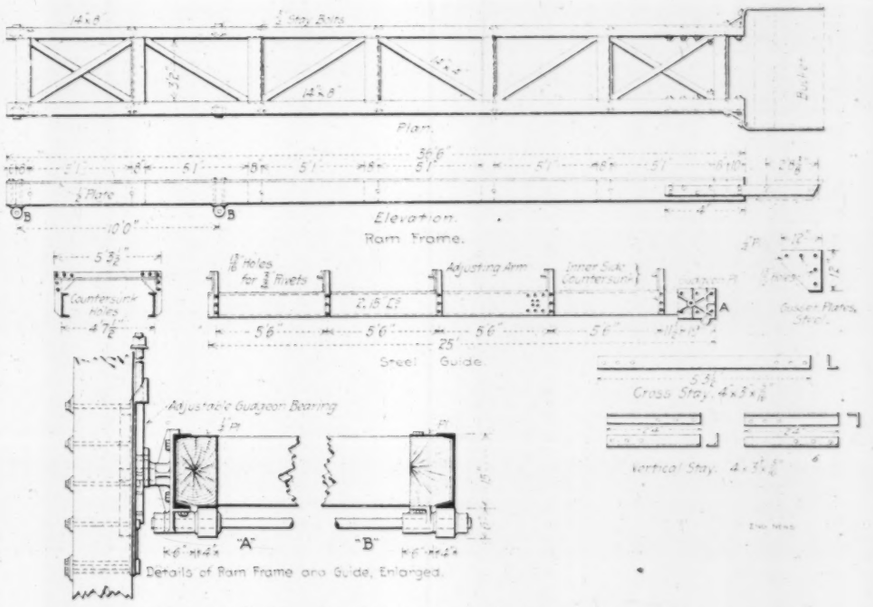

FIG. 2. DETAIL OF THE RAM AND GUIDE, LACHINE CANAL CONCRETE WORK.

ballast to place, and saw the toe properly braced with large flat stones lowered down for that purpose. The top of the form was placed in alinement by setting off the given distance from the base line. In some places the top of the bank or revetment wall was so badly washed that it was not possible to take a line from it. The top of the form was secured to the bank by timber braces and cables to anchor blocks placed at convenient points.

OPERATING THE RAM.—After the forms were ready, the mixing scow was floated into place, the arm run out over the bank and moored at rest over the longitudinal beams arranged to slide it forward on, when the scow was moved.

Tests were now made in lowering and raising the ram, and, beyond the usual stiffness expected in new machinery, everything worked satisfactorily.

A few batches of concrete were next tried, and it was noticed, as the bucket was lowered, that the water which rushed in at the top caused no violent washing out of the cement. After a little experience in lowering the ram, no discoloration of the water appeared, which showed that the cement was not being washed away. The ram was run to the bottom, about 23 ft. on the slope, and, as the concrete filled in below, it was found quite easy to judge the proper point at which to stop the ram. This operation was continued until the top was reached, and a section of about 20 ft., at bottom, was filled before the plant was moved forward. The scow was moved about every 8 or 10 ft. as the work progressed. When the concrete reached to within 4 or 5 ft. of the top of the wall it was found unnecessary to use the ram, and the concrete was allowed to flow into place from the open bucket.

CONCRETE INGREDIENTS.—The clause of the specification governing the above was partly as follows:

Concrete Ingredients.—The concrete shall be made in the proportions of one barrel of cement, three barrels of sand, and six barrels of crushed stone, or in such other proportions as may be ordered by the engineer in charge.

The sand (provided by the contractor) shall be coarse-grained, sharp, and silicious, free from earthy or vegetable matter. A sample of the same which the contractor wishes to provide must be furnished to the superintending engineer before any is brought on the work.

The stone ballast (provided by the contractor) shall be crushed hard grey limestone, or "banc-rouge," crushed to pass through a 2-in. ring. The run of the crusher shall be used, and the crushed material must be transported and stored so that no earthy or foreign matter of any kind is intermixed.

All dirty or unsuitable materials shall be removed from the site of the work as soon as ordered by the engineer in charge.

This proportion was usually adhered to, except that a slight variation was made with any change in the sand or the stone provided.

The usual mix was about 30 cu. ft. of stone, measured loose, 13 cu. ft. of sand, and 4½ to 5 bags of cement. This rarely exceeded a yard of concrete when settled in the work.

The sand was usually from the Lake of the Two Mountains, one grade being largely retained on the 50 and 80 sieves, the other being considerably coarser. The latter was chiefly used.

The crushed stone used was what is called Potsdam quartz, or Laurentian sandstone. It is hard, creamy white, gritty stone, apparently somewhat porous, but possessing an ideal surface for cement to cling to.

Barges holding about 200 tons were employed to carry the stone, and the barges could be filled from the bin direct in about twelve minutes. The haul was about 24 miles.

The run of the crusher was always used, as is demanded by all of the Lachine Canal specifications for crushed stone for concrete ballast, the maximum size being about 2 ins. Our experience is that, with probably one exception—viz., a hard, brittle limestone—the run of the crusher, without screening, gives a broken stone that will make the best concrete.

The maximum size of the stone specified is 2 ins. At times, however, with the Potsdam quartz, flat pieces, longer than 2 ins., passed through the crusher, and at first were rejected, but after an examination of the wall, it was found that these larger size stones gave a good bond to the mass, especially when worked near the front and at an angle to the wall. The benefit of these long pieces was seen when the wall was examined during the unwatering the following April. At the water-line, where any wash occurred from the waves caused by passing steamers, the larger stones projected into the mass sufficiently to permit the ballast from becoming loosened and falling down. In fact, these projecting pieces could not be moved, even with a hammer blow.

CEMENT.—Selecting the cement proved a little more difficult than in ordinary work. A number of good Canadian brands were on hand, as usually the Lachine Canal carries a stock of from 20,000 to 30,000 bbls. in the sheds, but some of the brands gave more even setting results than others.

In the laboratory tests these cements all set in about the same time, but varied on the work. This was largely due to the fact that the temperature of the water was changing, being warmer towards summer and colder as the autumn approached.

The cement was provided by the Department, but the contractors demanded a medium quick-setting cement in order that they might remove the face forms every three days.

On one occasion, pending the letting of a new cement contract, some English cement was used. This was a first-class cement, but slower setting than the Canadian, and it was found at the end of three days that the concrete was still soft, and the form could not be moved for a week.

Results of the Work.

An examination of the work, after unwatering the canal on the April following the first season's operations showed satisfactory results, and several points are worth noting. First, that the placing of the concrete had been continued too late in the fall (to October 24), and as a result of the condition of the water (its low temperature) the concrete of this section, compared with the other concrete, was found to be quite weak. The concrete placed in September had set up hard, and withstood the action of the ice when the water was let out of the canal in April, but the wall placed late in October had grooves cut into it by the ice sliding down, and on this account cost the contractors a considerable sum to refinish the surface.

Second, while some portions of the wall near the water-line had been acted upon by the wash of the waves from passing steamers, and looked rough, it was very hard and firm. The projecting stone from the ballast, particularly those pieces longer than two inches had secured such a grip in the wall that it was impossible to dislodge them.

The lower portion of the face was quite smooth, but the slope made by each section of concrete laid, as the scow was moved ahead, was discernible. It showed that sections of over 8 ft. before moving the plant were too long.

The top surface, usually flooded for a portion of the time after being finished, showed no signs of scumming, but a portion finished late in October one year, followed by rather severe cold in November, was found, after the snow had melted in the following spring, to have peeled to some extent. The warm sun of April, when the canal was unwatered, had the effect of hardening up any portions of the wall that had been delayed in hard set by the coldness of the water.

Laitance, or scumming, of the concrete surface has not been found to any extent on this work, either in the locks, basins, or in the general foundation work.

The information thus gained was made use of during the second season of the work. The scow was moved ahead about every 8 ft. and additional precautions taken to prevent the steamers creating such heavy wave action by making them slow down at a greater distance from

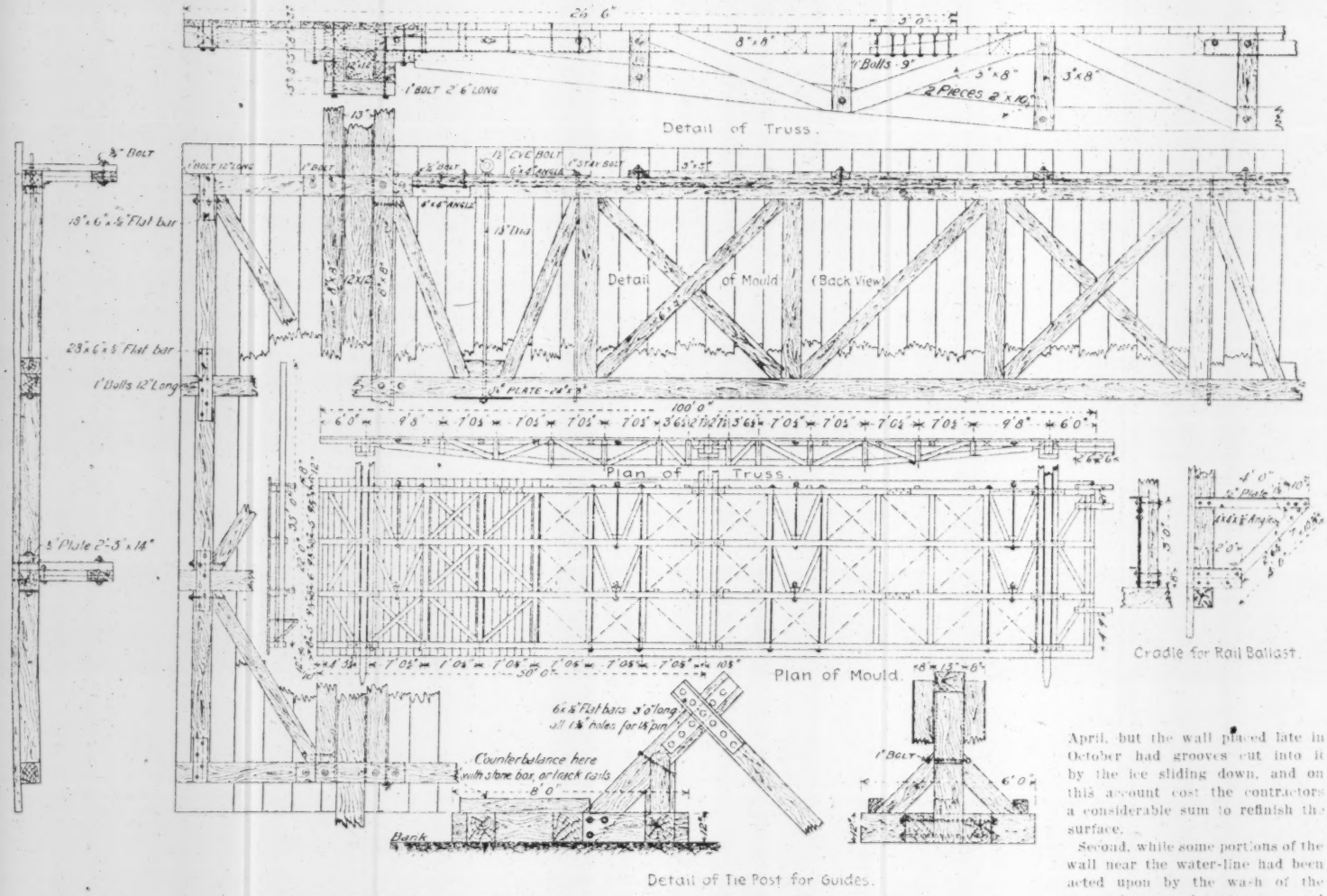
Detail of Truss.
Detail of Mould (Back View)
Plan of Truss.
Cradle for Rail Ballast.
Plan of Mould.
Detail of Tie Post for Guides.
Counterbalance here with stone box, or track rails
Blank

FIG. 3. DETAILS OF THE FORMS FOR THE SLOPE WALLS, LACHINE CANAL.

the plant. The work was discontinued earlier in October, instead of waiting till the water had become too cold.

On examining the second season's operations on the following April, good results were found all along the wall, and the finish at the bottom was remarkably smooth.

The ice had no injurious effect. The stone ballast was exposed in portions of the face, but only slight repairs were required. The action of the ice is one reason for making the concrete facing on the Lachine Canal so thick. About one mile of the concrete facing on the north side was laid with a view to stopping a heavy leakage through the bank. The result was entirely successful.

On the Kaiser Wilhelm Canal, where concrete had been placed on the bank in the dry, "it was noticed, even during the construction of the works, that many of the slabs had hardened only at the surface, and that a year afterwards the lower part was still soft and pasty. This was due to the fact that they were laid upon turf and other soil where there was a discharge of organic acids, which had a tendency to unite with the chalk of the cement in such a way as to make soft soap."

The conditions of the Lachine Canal were not such as to create the difficulty above described. There are no peaty banks, although peat and marl abound in the ground back of the north bank.

A peculiar result was noticed at one portion of the wall. A cavity existed under one of the forms which was missed by the diver. Through this the richer portions of the concrete ran out, and covered about 6 or 8 ft. of the bottom of the canal to the thickness of a foot or upwards with a regular mortar. When the section was examined during the following April (1909), the above condition was found, and, strange to say, the mortar was almost in a plastic state, although the portions of the wall above, below, and opposite this point were hard. This mortar hardened up as it became exposed to the air during April, but still was unlike the rest of the wall. The inference from the above, and the rusty color of the mortar, was that, having lost the protection of the face boards, the mortar had, before setting, become affected by some of the discharges into the canal from the mills above and its setting retarded. The other portions of the wall had not been affected, as the forms protected them until the concrete had been set.

Whatever the organic matter was in these discharges from the mills, it had no injurious effects on the walls, although portions of them near the factories are highly discolored.

Cost of Operating Plant.

An analysis of the cost of the work, to be of value to an engineer, must cover the details of the operating gangs required for each part of the plant, and give the results, the combined units accomplished, in a given time. The cost of materials, sand, stone, coal, oil, etc., will depend more or less on local circumstances, and need not be considered here.

The general experience is that a large plant requires a number of extra men, not usually provided for when the plant is designed. It must also be remembered that the time spent in getting ready and laying up, if the operations go over more than one season, must not be overlooked, as in many cases this is an expensive item, and unusually so with a floating plant in this country.

The gangs employed on this plant were as follows:

Lifting Scow.—1 foreman, 4 cranesmen, 1 diver and 2 assistants.

Mixing and Depositing Plant.—1 hoist runner, 1 fireman, 3 trimmers for stone and sand barges, 1 mixer operator, 1 man measuring and feeding materials to car, 1 car operator, 2 men handling cement from barge to scow, 1 man opening cement bags, 1 man feeding cement to car, 1 operator for ram, 1 man operating door of bucket, and 1 man collecting empty cement bags.

Men Employed on Banks and Scows.—1 carpenter and 4 helpers for adjusting beam runs and rollers for moving arm of ram, 1 man leveling concrete surface, 1 foreman on barges for sand, stone, and cement, and 10 men on latter.

Supervising Staff.—1 general superintendent, 1 master mechanic, 2 assistant mechanics, 1 carpenter foreman. These were all high-grade men in their class, and were kept employed on the work about eleven hours each day.

The transportation plant consisted of two tugs, eight or nine barges, including covered-in barges or scows for cement storage, and a barge for coal. The cost of this part of the outfit would be probably charged up to the cost of supplies, etc., and need not be considered here. A small repair gang was generally required, and kept on call for repairing the floating plant. This latter item is one that should be carefully considered and allowed for on similar plants. Some contractors, the author has observed, neglect this, but it was not so with the contractors for this work. One good carpenter and three or four helpers should be provided for the maintenance of a plant of this kind, even if new at the start.

The capacity of the plant averaged about 200 cu. yds. per day of ten hours. This was sufficient to fill in behind about one length and a third of the forms used—that is, about 130 ft. lineal, of finished wall surface each day. The record is about as follows:

1907, from June 5 to Oct. 24	20,000 cu. yds.
1908, from May 15 to Oct. 17	30,000 cu. yds.
1909, from May 12 to June 21 (finish)	6,000 cu. yds.
Total	56,000 cu. yds.

The time from the 1st of May in each year till the date of beginning work was spent in getting the plant in commission. This bears out the remarks previously made regarding the cost of getting ready and laying up floating plants.

On the completion of the work on the Lachine Canal the plant was removed to the Soulanges Canal, where the contractors had secured a contract for a similar piece of work. The slope of the walls, however, in the latter case, was flatter than those on the Lachine Canal, but with some slight changes, the author is informed, highly satisfactory work was done.

Conclusions.

The three seasons' experience in laying concrete under water is sufficient, in the opinion of the author, to show that there is practically no limit to this class of work, provided the space can be confined and heavy currents overcome. As was pointed out by Mr. Vernon Harcourt some years ago, "the chief difficulty is found near the low-water mark in cases where there is a fluctuation of the water-level, and just above and below where there is a wash."

The "mix" should be, in the majority of cases, what might be termed a "wet putty mix," and experience shows that more washing out will occur if the "mix" has a tendency to be too dry rather than too wet.

A few tests will show what percentage of water is best suited to the grade of materials used.

In connection with the use of water in concrete, it may not be out of place here to warn those about to select a mixing plant, that the water tanks usually supplied by the makers are too small, and that the automatic measuring system is generally unreliable.

Our experience is that a 40-gal. cask is small enough, and that a 60-gal. one is much better.

A given quantity of water, regulated by the automatic valve, the quantity figured for a theoretical "mix," is of little use on actual work. In many cases the absorption of the dry materials alone will take all the water originally estimated for the entire batch; in fact, the amount of water also changes with the daily variation of temperature and humidity.

The man in charge of the water must be trained to use his eyes and some judgment as well as to turn a valve, and the only mechanical perfection required is a tight valve and a quick turn-off.

The author is indebted to Mr. A. T. Gibson, Toronto, member of this Society, the engineer for the contractors, and to Messrs. Haney, Miller, Quinlan and Robertson for permission to use the original drawings of the plant.

The work was carried on under the supervision of the Department of Railways and Canals, through Mr. E. Marceau, the superintending engineer of the Quebec canals, and the author, as engineer in charge of the Lachine Canal.

Mr. Angus W. Robertson was the direct representative of the contractors on the site, and, with the author, was enabled to follow out daily the operations of the plant and the results attained.

Effect of the Length of Penstock on the Weight of Revolving Parts of a Water-Wheel Unit.

By GEORGE M. PEEK.*

It is impossible to attain any satisfactory degree of regulation of a water-wheel unit fed by a long closed penstock, unless the revolving parts are made of proper weight. A turbine with long penstock which has insufficient weight in the revolving parts will gain in speed excessively when the gates are being closed by a quick-acting governor.

When the governor closes the gates suddenly there is a rise in pressure in the penstock, and it has been stated that there may be a momentary increase in discharge. This cannot be, although there may be, and generally is, a momentary increase in *energy* delivered to the turbine. For in order that there be an increase in pressure in the penstock there must be a retardation in the velocity of the flow in the penstock; hence it is impossible to have an increase in discharge. But the energy delivered to the turbine is proportional to the weight of the water multiplied by the square of the velocity of efflux. When the water is suddenly checked by the gate the pressure may rise sufficiently to cause an increase in the velocity of discharge such that the energy delivered to the turbine is increased momentarily in spite of the reduced gate-opening.

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In the following discussion the notation used is:

L = length of penstock, in feet.
p = rise in pressure due to decrease in gate opening.
v_1 = normal velocity of the water in the penstock.
v_2 = velocity after change in gate opening.
F = retarding force.
m = mass of the water whose cross-section is one square inch and whose length is equal to that of the penstock.
g = acceleration of gravity = 32.2.
T = time required to change the gate opening.
P = horsepower of the turbine.
W = the combined weights of the revolving parts of the unit.
E = energy absorbed or given out by the revolving parts due to a change in speed.
R = radius of gyration of the revolving parts.
N = speed of the turbine, in revolutions per minute.
δ = percentage of speed variation.

The formula

$$p = 0.0134\ L\ \frac{v_1 - v_2}{T}$$

seems to be the one very largely used for determining the increase in pressure due to a change in the velocity of water in the penstock. But in actual practice the pressure seems to go higher than would be indicated by this formula. I would suggest the following solution:

If we have a mass m moving with velocity v, the kinetic energy would be $\frac{1}{2}\ m\ v^2$. If the mass be brought to rest with uniform retardation in time T, the distance through which it will move will be $\frac{1}{2}\ v\ T$. If the retardation is caused by a force F, the work done by the force in bringing the mass to rest would be $\frac{1}{2}\ v\ T\ F$, and this must be equal to the kinetic energy, or

$$\tfrac{1}{2}\ v\ T\ F = \tfrac{1}{2}\ m\ v^2.$$

In case of a change in velocity instead of a stoppage, the kinetic energy changes by the difference between initial and final energies, $\frac{1}{2}\ m\ (v_1^2 - v_2^2)$; the average velocity of the force is $\frac{1}{2}\ (v_1 + v_2)$, and the work done in changing the speed must equal the change of kinetic energy, or

$$\tfrac{1}{2}\ (v_1 + v_2)\ F\ T = \tfrac{1}{2}\ m\ (v_1^2 - v_2^2)$$

so that

$$F = \frac{m\ (v_1 - v_2)}{T}.$$

In a penstock, during closure of the gate at the lower end, the increase of pressure is the retarding force, so that the force is not constant as above assumed. In the absence of more definite information concerning the rate of increase in pressure we may assume that the pressure rises uniformly. In that case the maximum value of p will be twice the average, and the above formula would be changed to read

$$p = \frac{2\ m(v_1 - v_2)}{T}$$

Since in the derivation of this formula the elasticity of the penstock and the compressibility of the water have not been considered, it may be assumed that the rise in pressure would never actually reach the above value. A safe and conservative value for p may be

$$p = \frac{3}{2}\ \frac{m\ (v_1 - v_2)}{T}$$

or, since $$m = \frac{62.4\ L}{144\ g} = 0.0134\ L$$

$$p = 0.0201\ \frac{L\ (v_1 - v_2)}{T} \qquad (1)$$

$$\text{and } T = 0.0201\ \frac{L\ (v_1 - v_2)}{p} \qquad (2)$$

In order that the turbine or water-wheel may

be properly governed, the length of penstock and the velocity of the water in same should be known, together with the specified allowable speed variation, in order that the rise in pressure in the penstock and from this the weight of the revolving parts may be determined.

The energy stored in the revolving parts is

$$\frac{W}{2g}\,\frac{4\pi^2 R^2 N^2}{3600},$$

and the energy which would be absorbed or given out by the revolving parts due to change in speed from N to N_2 would be

$$E = \frac{W}{2g}\,\frac{4\pi^2 R^2}{3600}\,(N^2 - N_2^2).$$

But $N_2 = N(1 \pm \delta)$, so that

$$E = \frac{W}{2g}\,\frac{4\pi^2 R^2}{3600}\left[N^2 - N^2(1 \pm \delta)^2\right]$$

$$= \frac{W R^2 N^2}{5872.9}(\pm 2\delta + \delta^2)$$

Since δ is a small quantity its square may be neglected; then we have

$$E = \pm\,\frac{W R^2 N^2 \delta}{2936.4}$$

The negative sign indicates that the revolving parts absorb energy upon a rise in speed.

When the full load is thrown off the unit, the governor closes the gates, and the shutting off of the power may be considered to be uniform. The average horsepower delivered to the turbine while the governor is closing the gates would be $P/2$, or the work input $550\ P/2$ footpounds per second. Therefore the total energy delivered to the turbine during the closing of the gates would be $550\ PT/2$. This unconsumed power must be stored in the shape of increased kinetic energy of the revolving parts, *without exceeding the allowable variation of speed*; for this purpose we must have

$$\frac{550\ PT}{2} = \frac{W R^2 N^2 \delta}{2936.4}$$

$$\text{or } W R^2 = 807540\,\frac{PT}{N^2\delta} \qquad (3)$$

Combining equations (2) and (3) we have

$$W R^2 = 16232\,\frac{P L (r_1 - r_2)}{p N^2 \delta} \qquad (4)$$

EXAMPLE.—The following example may be taken to illustrate the use of the above formulas: Suppose we wish to determine the weights of the revolving parts of a 5,000-HP. unit working under an effective head of 120 ft. at 300 r. p. m., the penstock being 600 ft. long with a normal velocity of flow in same of 6 ft. per sec. The allowable speed variation from full load to no load is limited to 8% and the rise in pressure in the penstock, when full load is thrown off, must not exceed 50 lbs. per sq. in.

Here $r_1 = 6$. After the full load is thrown off the velocity in the penstock need only be sufficient to keep the unit up to speed, and practically r_2 may be considered as zero. Then we must have, by formula (4),

$$W R^2 = 16232\,\frac{5000 \times 600 \times 6}{50 \times 90000 \times .08} = 811600$$

For instance, if the radius of gyration R equals 4 ft., W must be 50,730 lbs.

Solving eq. (2) to find the time in which the governor must close the gates in order to fulfill the above conditions, we have

$$T = \frac{.0201 \times 600 \times 6}{50} = 1.44 \text{ sec.}$$

The question would arise as to whether or not the speed could be kept within the limit when the load is thrown on the turbine. If we assume the grade of the penstock to be uniform the sine of the angle of inclination would be $\frac{120}{600} = 0.2$.

The force of gravity acting in the direction of the penstock would be

$$g_1 = g \times 0.2 = 32.2 \times 0.2 = 6.44.$$

Then from the gravity formula $v = g_1 t$ we have $6 = 6.44 \times t$ or $t = .95$ sec., where t is the time required for gravity to produce a velocity of 6 ft. per sec. in the penstock. Since this is less than the value 1.44 sec. found for T, the drop in speed when full load is thrown on will be within the 8% as assumed for the problem.

The above method of determining t neglects the effect of friction in the penstock; but as the average velocity during acceleration would be small the effect of friction would be small, and the value of t would probably remain below the value 1.44 sec. found for T.

Summary of Recent Congressional Conservation Legislation.

As many of our readers know, there was organized not long ago a National Conservation Association with the object of doing all that is possible by concerted, intelligent, private effort to further the conservation of the natural resources of the country. The Association has its headquarters at Washington, D. C. Its first president was Dr. Charles W. Eliot, until recently at the head of Harvard University. After the deposition of Mr. Gifford Pinchot as Chief of the U. S. Forest Service, Mr. Pinchot was made President of the Association. We give below a summary of the Congressional Legislation on Conservation, together with some account of bills still pending before Congress at its recent adjournment, all as printed in a Bulletin of the National Conservation Association, dated July 26, and signed by Mr. Pinchot:

Bills Advocated by the Association.

Measures within the field of Conservation whose passage was advocated by the Association and the results accomplished are as follows:

THE PUBLIC LANDS WITHDRAWAL ACT (PUBLIC 303), INCLUDING ALASKAN COAL LANDS.—The Hon. James R. Garfield presented the views of the Association as to this bill before the Senate Committee on Public Lands, which accepted his suggestions. Subsequent modifications changed the bill for the worse, and, in particular, opened lands withdrawn for water-power and other purposes to private appropriation under certain of the mineral land laws. But the bill as finally enacted goes far beyond the recommendations of the Administration, and of itself alone more than justifies the work of the Association during the entire session. It was under the authority of this Act that the recent withdrawals of public lands were made.

It is particularly gratifying that by renewed withdrawal the Alaskan coal lands are protected, temporarily at least, from the predatory interests which threaten to absorb them.

THE INDIAN AND THE STATEHOOD ACTS.—The Omnibus Indian Act (Public 313) expressly authorizes the reservation of power and reservoir sites on Indian Reservations. The Act (Public 219) for admitting New Mexico and Arizona as States makes similar reservation upon lands granted to the new States, while the Withdrawal Act (Public 303) expressly includes water-power sites as one of the purposes for which the President's power of withdrawal may be exercised. This provision was not in the bill as drafted by the Administration. The right of the people to receive returns for valuable water-power sites granted to private interests, for which the Association contends, is recognized in several pending bills. Other bills recognize that 50 years is long enough for the life of any such grant.

The Omnibus Indian Act (Public 313) authorizes the sale of mature, living, dead and down timber on all Indian Reservations, and so at last makes possible the conservation of all Indian Forests on a scientific basis.

THE APPALACHIAN AND WHITE MOUNTAIN FOREST BILL.—The bill (H. R. 11798) for the purchase of the Appalachian and White Mountain National Forests has again passed the House and an agreement has been reached under which it will be finally voted on in the Senate on Feb. 15, 1911. It is by no means unlikely that this measure, for which the friends of Conservation have been contending for more than a decade, will at last be made law.

SEPARATION OF SURFACE FROM UNDERLYING MINERAL.—Conservation of coal, which means the prevention of theft and waste, and not the prevention of use, is powerfully assisted by the passage of the Act (Public 227) which provides for disposing of the surface of lands withdrawn, classified or known as coal lands, separately from the underlying mineral.

BUREAU OF MINES.—The creation of a Bureau of Mines (Public 179) opens the road not only to very large savings in the waste of coal, but what is more important, to the prevention of the waste of human life in coal mining accidents.

These are among the forward steps in the field covered by the Association. They represent a small portion of the definite Conservation program worked out under the Roosevelt Administration. There is much more to be done, but this much marks real progress.

Bills Opposed by the Association.

PROPOSED GRANT OF WATER-POWER SITES TO THE STATES.—The main purpose of this bill (S. 7432) was to transfer to Western States all the powers and responsibilities of the National Government, with respect to water-power development on lands owned by the Nation. In Bulletin No. 3, which the Association issued on this bill (April 9), the position was taken that the Nation is morally bound to exercise for the general welfare its constitutional power to dispose of and regulate the public domain, and that in surrendering its land title to power sites, and therefore the control of their present and future use, the Federal Government would be shirking its duty to the people, whose property it holds in trust. The Association believes that the passage of the Smoot Bill would put the uses of water-power completely in the hands of the big water-power interests and that it would give them precisely what they wanted and had sought in vain in the last Congress and Administration. Therefore, the Association vigorously opposed the bill. It was not passed, but it is still pending in the Senate.

THE JAMES RIVER DAM BILL.—The Association opposed the bill to license a power dam in James River, Missouri (S. 374), on the grounds that it granted unrestricted control of a natural resource for an indefinite time without compensation to the people; and that it authorized the obstruction of a navigable river for private profit without assurance that the place, nature and extent of the obstruction were in harmony with any systematic plan for improving navigation, and without utilizing the power value of the stream to help defray the cost of its improvement. The Association issued a bulletin against this bill on May 5. The bill was not passed.

OTHER WATER-POWER BILLS.—Other water-power bills were introduced by Senator Carter, of Montana (S. 5704); Senator Hughes, of Colorado (S. 8025); Representative Smith, of California (H. R. 11932), and Representative Englebright, of California (H. R. 23586). These bills would have granted water-power sites now in Federal ownership to the States, or would have subjected them to condemnation by power companies under State laws. Either course would have sacrificed all Federal rights of control. The Association opposed the passage of all these bills. None of them have been enacted into law, or favorably reported for passage.

Other Conservation Measures.

The General Dams Act (Public 246), passed at the last session of Congress, provides that in approving plans for dams the War Department must consider the systematic development of the river for navigation and require the general plan to conform thereto. This has not been hitherto the case. Licenses are for the first time limited to 50 years. But the principle of compensation to the people is recognized in so restricted a form as to be in substance nullified. The Association opposed this feature of the Act, but without success.

For the same reason the Association opposed the Omnibus Dams Bill (H. R. 26081) to grant 16 separate licenses for the obstruction of navigable rivers in different parts of the country under the conditions fixed by the General Dams Act. This bill did not pass.

The River and Harbor Act (Public 264) recognizes the interrelation of power and navigation.

It is unfortunate that the Interior Department has absolutely refused to approve rights of way for municipal water-supply, irrigation and water-power wherever the lands affected are believed to be valuable for water-power. This policy has continued for a year. It amounts to the absolute stoppage of water-power development throughout the arid West, and has done much to create the totally false conception of Conservation in that region. The Forest Service has wisely rejected the proposals of the Interior Department looking to the establishment of the same policy in National Forests.

THE CONSTITUTIONALITY OF THE U. S. RECLAMATION act has been upheld by the U. S. Court of Appeals, in connection with a suit brought by one David Burley, of Idaho. According to press despatches the main point of the decision was:

Burley contended that the act which permitted the Government to condemn his lands and water for irrigation purposes was unconstitutional on the ground that the water stored in the reservoirs sought to be taxed was not wholly for public use, but was to be supplied to private landowners by the Government as well. The decision establishes the right of the Secretary of the Interior to acquire by condemnation or otherwise lands and waters in the furtherance of reclamation projects.

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When the Hoboken trainshed of the Delaware, Lackawanna & Western R. R. was built, five years ago, the novelty of its design won widespread credit for its designer, the then Chief Engineer of the railway, Mr. Lincoln Bush, M. Am. Soc. C. E. The success of the trainshed in operation, and the adoption of the same design elsewhere, enhanced that credit. A letter which was published in our issue of June 16 tended to detract from that credit by attacking the originality of Mr. Bush's design. The letter stated that Mr. E. I. Cantine and Mr. J. H. Philips, as a result of a trip of investigation to Philadelphia for the Lackawanna, had conveyed to Mr. Bush various ideas on trainshed construction, which entered into the design of the Hoboken trainshed.

We have since made careful inquiry as to the statements and implications made in this letter in so far as they relate to Mr. Bush and the designing of the Hoboken trainshed, and have received the written statement of Mr. Cantine and affidavit from Mr. Philips, denying the allegation unequivocally.

We have also received statements, under oath, from other officials of the Lackawanna of that time and the present time, that the Lackawanna did not design or call for bids or receive bids on a trainshed of the inverted-umbrella type, the Bush shed being the only one on which bids were asked. These affidavits further bring out the important point that the original complete detail tracing of the Bush design was finished May 3, 1905, whereas the trip to Philadelphia* by Messrs. Cantine and Philips was not begun till May 5, 1905, and was not reported till May 9, 1905.

*The "trip" to Philadelphia was a stopover incidental to an inspection trip to Harrisburg, Altoona, Marysville and Enola, Pa., to inspect hump yards. Without request or authority from Mr. Bush a short stopover was made at Philadelphia to inspect the methods of handling express, baggage and mail at Broad Street and West Philadelphia stations. Mr. C. H. Ketcham, former Division Superintendent of the Lackawanna, was in the party, though not mentioned in the letter. He has also made affidavit, which fully agrees with the statements of Messrs. Cantine and Philips.

It will be evident that this completely destroys the imputation made, and leaves Mr. Bush's credit for the design undiminished.

The economic advantages of proper organization and methods for everyday work are the basis of frequent discussions at meetings of engineers, and the trend of the discussion is usually in the line of endorsing methods of this kind on the ground of both economy and efficiency of the work performed. Examples of lax and inefficient methods are met with so frequently, however, that one is led to wonder sometimes how far those who endorse the principle carry it into effect.

Two instances which have come to our attention recently will illustrate our meaning, and while both relate to railway improvement work, they may be considered as typical of instances on various other kinds of work. The first instance is that of steam-shovel work in widening the roadbed of a trunk line for sidings and yards. Much has been said and written as to the desirability of keeping such machines steadily at work by proper equipment and organization of the work-train service, and these ideas are generally accepted. In the case to which we refer, a large and powerful shovel was used, and there was a powerful locomotive for the work train, but the supply of cars was so small that the shovel stood idle for a material portion of its time. The other instance relates to the unloading of rails for rail renewals on a double-track main line. It has been pointed out many times that rails represent a considerable amount of money and that they are liable to injury by careless handling, so that particular care should be taken in unloading them along the track. These facts are generally recognized, and numerous appliances and methods have been devised for performing this work easily, quickly and cheaply. In spite of all this, however, on the work in question (and, we must believe, in many other cases) the rails were simply hauled out and allowed to drop on the ties. As two rails were unloaded at each halt, the second rail invariably fell upon the first. Examination of the rails would probably show kinks and notches attributable directly to the method of unloading, and these (with other defects perhaps not easily seen) may develop flaws and cracks in service.

Both the cases cited were on what rank as "first-class" roads with large and (presumably) well-organized engineering and maintenance departments. Both occurred, also, within 30 or 40 miles from headquarters, and they indicate the desirability of "jacking up" some officials. Probably the officer in charge has a large number of similar jobs under his general direction, and such an officer cannot be expected to give his personal attention to the details of each job. But he should certainly see to it that his staff is so organized and instructed that the work will be done by proper methods and with proper records as a check upon the working efficiency of his staff and their men. If this was done there would not be so many examples of waste of time and misuse of material.

We are not concerned specially, of course, in the criticism of the two examples cited. There may have been reasons for the defective conditions, although it is difficult to imagine any good reason for handling new rails like so much scrap iron. Unfortunately, however, these are examples of the way in which many jobs of similar character are carried on, and this is true not only of railways, but also of municipal work and other lines of construction and repair.

The economic advantages of proper organization and methods are pretty well understood (in theory at least) by the higher officers in charge of such work, but evidently there is a direct necessity for seeing that the work is carried on in such a way as to obtain these advantages, and for impressing this necessity upon the assistants forming the staff upon which the superior officer must rely for the actual conduct and supervision of the work. If he is content to consider this as a matter of theory, only, or inapplicable to the many minor jobs which enter into improvement or maintenance work, it cannot be expected that the work in general will be characterized by a high degree of economy or efficiency.

Why do so many of our cities persist in building discredited types of garbage and refuse furnaces? A member of the editorial staff of this journal recently visited a city garbage furnace for the third time; or rather furnace No. 3, for on each successive visit a different furnace at a new location was found. On the first visit, some fifteen years ago, operating results, as regards combustion of the refuse, seemed to be better with furnace No. 1 than are now being obtained with No. 3. Of course this may be due to the engineers in charge, but the engineer of the present plant complained that the furnace now in use was wrongly designed in that the refuse is dumped vertically direct onto the fire and that the fire is checked each time a load of refuse is dumped; also that in the absence of provision for forced draft he had to depend entirely on his chimney. Certain it is that the stokers were removing "ashes" which contained unburned paper. Practically no garbage seemed to be coming to the works.

What excuse is there for a city to buy such a furnace when for years past furnaces have been designed and built which make every conceivable provision for complete combustion of not only the refuse itself, but also the resulting gases, and for charging the furnaces so as to offer the minimum check to the fire? None but ignorance. As we have repeatedly urged, the selection of a furnace to burn garbage and other city refuse is an engineering question. And yet, it is but rarely so regarded in America. Month after month the installation of a garbage furnace comes up in one or more of our cities, and is left to the wisdom of some councilmanic committee of laymen. The ensuing procedure is too well known to require description. The results may be seen almost anywhere from the Atlantic to the Pacific, the Gulf to the Canadian border, in the shape of abandoned furnaces, or furnaces operating in a haphazard fashion, with smoky chimneys, half-burned refuse pulled out by the stokers and a general air of dirtiness and dilapidation.

Why have the American furnaces, as a rule, been such failures? Simply because scarcely one of them has been designed and built by a competent engineer. Even the first British refuse furnaces of the late 70's seem to have been much better than ours of the 80's, although it should be noted that we tried to burn relatively wet garbage and even night soil, whereas the British furnaces coped from the first with a relatively dry mixed refuse, containing a large percentage of combustible matter.

This long succession of failures in the refuse burning branch of the municipal service has been broken in a few recent instances by taking advantage of the latest engineering knowledge of the subject. The refuse incinerator at Milwaukee, Wis., described at length in our issue of July 14, 1910, is a notable example of a change in the right direction.

Since the extension of the Chicago water intakes and the diversion of the sewage of the city from the lake by means of the Chicago drainage canal, the typhoid death rate of that city has fallen to a low point as compared with most American records, but one which is still notably above the rate of an imposing number of foreign municipalities. As a part of the vigorous general campaign which is being waged by the Chicago Department of Health, arrangements have just been made which are designed to still further reduce the Chicago typhoid death rate. To this end Dr. L. L. Lumsden has been detailed by the U. S. Public Health and Marine-Hospital Service to take a hand in the study and control of typhoid in that city. The medical inspectors and the laboratory of the Health Department will

report typhoid information to Dr. Lumsden, and he will also have the help of a large body of nurses connected directly or indirectly with the public-health campaign. In addition, he has asked the cooperation of every physician in the city who has a typhoid case. The Health Department stands ready to assist in typhoid diagnosis through its laboratory by means of examination of blood specimens, and in this work has been promised assistance from Prof. Jordan, of the University of Chicago.

As bearing further upon this campaign, we quote from the Bulletin of the Chicago Department of Health, for July 16, as follows:

> Every suspected case should be safeguarded as though it were known to be a case of typhoid fever. Have the stools and urine disinfected and screened at once. If the case does not prove to be typhoid no harm is done. The disinfectant recommended is a solution of *good* chloride of lime, one-quarter of a pound (about eight tablespoonfuls) to a gallon of water. The lime should be kept in a tightly covered metal can and the solution made up fresh each day. In hospitals, 4 to 8 gallons can be made up at once if it is to be kept in tightly stoppered bottles.
>
> Dr. Lumsden has had wide experience in investigation of typhoid outbreaks at numerous points throughout the country and is a recognized expert in this field. The doctor will be pleased to meet Chicago physicians, individually, or in any meeting that they may choose to arrange, to discuss the plan of campaign and to arrange the work in hand along lines of mutual helpfulness.

Obviously, not every city can expect to secure the assistance of the Public Health and Marine-Hospital Service in its efforts to control typhoid fever. We have no doubt, however, but that more assistance of this kind could be had if it were asked for. There are, too, plenty of experienced epidemiologists outside the federal service to meet any demand from cities likely to arise for some years to come. Certainly there is no question but that nearly every City Health Department in the country could do far more than it has yet done to ascertain and control the causes of the spread of various communicable diseases which every year result in so many deaths. Typhoid studies are needed in a large number of cities in order to learn why it is that notwithstanding the introduction of apparently satisfactory water-supplies, the typhoid rates still are far higher than in well-regulated foreign cities. The relation of water-supply to typhoid fever makes a direct appeal to engineers, and it is only reasonable to expect that they will interest themselves in it accordingly.

You Never Miss the Water Till the Well Runs Dry.

In the border-land between those portions of the United States which are absolutely dependent upon irrigation for its successful agriculture and those which need irrigation so infrequently as to make construction of irrigation works of doubtful expediency, if not wholly impracticable, there lies a considerable area which has a relative plenty of water in some years and is subject to killing droughts in others. This condition has been disastrous to thousands of farmers who have been encouraged by wet years to depend wholly upon the rainfall instead of providing safeguards in the way of irrigation works for use during the dry years.

The U. S. Reclamation Service act passed by Congress in 1902 contained a clause which time has proved has an important bearing upon the problems involved in the border-land conditions just mentioned. That clause, in effect, made it necessary to build extensive irrigation works in a number of states lying in the semi-arid region—or, if one prefers, the semi-humid region. This compulsion was due to a provision that, in so far as is feasible, money equivalent to the major part of the contribution to the Reclamation fund (arising from the sale of public lands) should be spent within the state contributing to the fund. As a result, several projects were entered upon where not only is there a fair amount of rainfall in some years but where, in addition, the only available water-supply for the irrigation of the lands included in the projects required pumping. These irrigation project systems, it will be seen, thus had a double handicap of no need or little need for water in some years, and of high operating charges caused by pumping expenses. Presumably, the high operating charges were in part offset by relatively low capital charges.

In the agitation over the U. S. Reclamation Service during the past few months some of the adverse critics blamed the Service for having undertaken these particular projects. It was pointed out in answer that the clause of the Reclamation Act already mentioned made virtually compulsory the establishment of irrigation works in the aforementioned border-land area and that the projects selected were the most promising of all those presented for consideration. It was also pointed out that although the people of these states, and particularly those who were to be benefited by the projects, were very solicitous for the construction of the irrigation works in question, yet after the expenditures had been incurred relatively few had come forward to use the water provided, while some even went so far as to claim that there ought to be no charge whatever for the water.

This state of practice and opinion, we wish to make it plain, appears to have been very largely due to the fact that following the opening of the irrigation works in question the rainfall was relatively plentiful so that the farmers could get along quite well without any other water-supply than that furnished by nature. These farmers seem to have experienced the same conditions and to have been in the same state of mind during the early part of the present season. Later on, however, a change occurred. This is set forth in an interesting way in the following brief official statement issued by the U. S. Reclamation Service under date of July 15.

> Farmers under the pumping projects in western North Dakota have been experiencing a wide variety of weather. On June 2 the ground was white with snow for a few hours. On June 20 the temperature was 102° F., accompanied by scorching winds. The total precipitation was 1.88, and as a result unirrigated crops were practically burned up. Many will not be worth harvesting, and the best yield that can be expected on dry land will not be 50% of normal.
>
> Very few applications for water from the Missouri River pumping plants were made early in the season. On June 1 only seven water users were entitled to water on the Williston-Trenton project, and practically none on the Williston project. During the latter part of the month the Service was besieged with requests for water. Owing to the great necessity for immediate relief the Reclamation Service officials increased their force and an effort was made to make prompt delivery, although the farmers were notified in advance to file a week's notice for the first delivery of water. About thirty men were employed on June 19 and on June 22 there was a force of 80 at work. The power and pumping machinery and canal system were operated at full capacity. The seven boilers at the power plant developed about 1,900 HP. As no such demand for water was anticipated the amount of coal available was somewhat limited, but in practically all cases good heads of water were furnished and irrigated crops are in excellent condition.

Perhaps the experience of the present year will lead the farmers under these irrigation projects to realize as never before how valuable it is for them to have an emergency supply at hand. Whether time will prove that the construction of these works would have been justified as a matter of agriculture economics, regardless of the mandatory provision of the Reclamation Act, it is perhaps too early to state. There seems to be no question, however, but what an experiment of this sort, whether on so large a scale or not, is well worth trying. Fortunately, the mandatory clause in question was repealed last June, so that hereafter the selection of irrigation projects may be based entirely upon their merit.

In conclusion, it will not be out of place to call attention to the fact that with the recent heavy fall in exports of our food products, due to increased home consumption, and the apparent rapid approach of the time when under present conditions our crops will not be sufficient even for our own needs, a notable change in agricultural methods is imperative. Among these will probably be the more extensive use of water for irrigation in the strip of land lying between the clearly defined areas where irrigation is an absolute necessity and where the normal rainfall makes general irrigation quite unnecessary.

The Rochester Sewage Disposal Case: Sewage Disposal by Dilution Strongly Endorsed.

Paradoxical as it may seem, the disapproval of the sewage disposal plans of the city of Rochester by the New York State Department of Health, on July 26, was really a virtual approval. While technically the plans were returned as disapproved they were really sent back for minor changes. The great principle underlying the plans—sewage disposal in water as a perfectly legitimate alternative, in some instances, to disposal on land—is established more firmly than ever before by this Rochester incident, as may be seen by reading the several detailed reports on the subject which we give in abstract elsewhere in this issue. At the same time, Commissioner Porter and Chief Engineer Horton, of the State Department of Health, have shown themselves to be firm, painstaking and withal judicial and practical conservators of the public waters, public health and other public interests of the great State of New York, with an open eye to the future as well as a grasp upon the present.

Briefly, the city authorities of Rochester sought approval of plans for diverting the sewage of that city from the Genesee River, where it causes a serious nuisance, to Lake Ontario, and there discharging it into deep water with no preliminary treatment save a slight period of sedimentation followed by fine screening. Nearly the whole burden of making the sewage both inoffensive and harmless was to be placed on the marvelous mechanical and biological changes wrought by the immense volume of the lake water into which it was proposed to discharge the sewage. In technically disapproving the plans, after securing outside expert advice, the State Department of Health merely insisted that the slight period of sedimentation be doubled, that scum boards for removing grease be added, and that provision be made for possible future extensions of the outfall sewer farther from the shore. No changes in the screens were suggested. The settling tanks were really little more than grit chambers, and might almost be called elongated screening chambers. Doubling the size of these tanks will give a total holding capacity of only 732,000 gals. The expense involved in the change and the net resulting effect on the sewage of a city of several hundred thousand population will be trifling. This is not saying that the change is not worth while. We mention its relative insignificance here only to emphasize the fact that the fundamental basis of the Rochester plans, sewage disposal into water, is in no wise altered or affected by the change demanded.

There is nothing new about discharging large volumes of sewage into water, fresh or salt. Almost every large city in the world does it, with little or no attempt to remove organic matter and with even less attempt to provide efficient means of bacterial purification.

The remarkable thing about the Rochester plans is that they are based on an unusually searching, intelligent, conscientious engineering study of all the local conditions at Rochester, including the capacity of the lake and its vital forces to assimilate sewage without harm or offence to man or animal.

When the resulting plans were submitted to the State Department of Health they had already received the approval of four members of the American Society of Civil Engineers. They have since been unconditionally approved by a fifth member and approved with suggestions for slight modifications by three other members. None of the suggested modifications affect the fundamental principle, already stated, that under certain conditions sewage disposal by dilution is legitimate from a sanitary viewpoint—as it unquestionably is from a financial.

Who are the eight members of the American Society of Civil Engineers who have subscribed to this doctrine, as applied to Rochester? Their names and positions in the engineering world are given in our presentation of the Rochester reports, elsewhere in this issue, but we may sum-

marize and characterize by saying that four are eminent engineers in private consulting practice; one is a leader among American city engineers; three have attained well-deserved recognition as Chief Engineers of the State Boards or Departments of Health of Massachusetts, New York and Pennsylvania. Four of these engineers acted on behalf of the city of Rochester and the four others represented the broader interests of the State of New York.

Anyone who is at all skeptical as to the justification of discharging practically unpurified sewage into water, under certain conditions, and after making careful studies to determine that those conditions really exist, will do well to read the extracts from the reports of Messrs. Hazen, Goodnough, Horton and Snow, given elsewhere in this issue. Those reports, as well as this whole Rochester case, including the decision of the State Department of Health, may well be regarded as marking an epoch.

In attempting to put forward this Rochester incident as a strong endorsement of the principle of sewage disposal by dilution we have not been unmindful of the fact that as an abstract ideal no unpurified sewage should ever be discharged into water. In like manner no unpurified sewage should be discharged on land. But, as we have often pointed out, and as Mr. Horton also states in his report, sewage disposal must be either on land or else into water. (Ultimately, the liquid portion of the sewage must reach the water in any event.) Both land and water possess the mechanical and vital qualities which will effect purification, so the choice, after eliminating dangers of infection, becomes one of relative cost and general expediency.

If the ideal in sewage purification was the only ideal before the cities of the land it might be practicable to prohibit the discharge of any sewage, not highly purified, into water. But as Mr. Snow forcibly states in his report, our cities are limited in their available funds and must choose those subjects of expenditure which will bring the highest returns in comfort, convenience and health. It is just this fact that is compelling many cities to adopt, and our State Boards of Health to approve, plans for sewage purification which to many people seem far from the ideal.

Judged by high standards of the present day the Rochester plans conform to what we may term a practicable ideal of sewage disposal. They abate the present nuisance in the Genesee River. They can scarcely affect any public water-supply to an appreciable extent, and any danger of the kind can be removed by water filtration, which latter will be demanded soon of all surface supplies in any event. The plans threaten no appreciable nuisance to sight or smell. The plans are readily adaptable to future changes in the disposal works, in the nature of biological purification on land or disinfection before the sewage goes into the lake, or by extension of the outlet into more remote and deeper waters. Such changes Mr. Kuichling provided for more or less designedly and the State Department of Health now specifically insists on, either as immediate alterations or possible future changes in the plans. The plans now have the approval of eight eminent engineers, including the chief engineers of four state boards or departments of health. What mortal could reasonably ask for more?

We have not heard of any one asking for more, but there have been those who have claimed for the changes demanded by the State Department of Health far more than those changes signify or the Department intended. In fact, it has been alleged that the disapproval of the plans was a great rebuke to Rochester and the engineers who prepared them. Nothing could be farther from the truth.

LETTERS TO THE EDITOR.

Transition Curves as Land Boundaries.

Sir: The following is a typical description with one company, and is found in many county records in the State of Washington:

Thence along the arc of a transition curve to the right, having a radius increasing uniformly from 2,864.9 ft. to infinity a distance of 160 ft.

Is it possible to approach infinity uniformly in 160 ft.? Will it not take more than one arc to do this?

Whose curve or what is it?

Can you guide me over this orbit and land me safely on the asymptote?

"Comet."

Embedded Wood in Concrete.

Sir: Referring to the several articles in your paper (July 21, 1910, p. 78; Aug. 4, p. 131) regarding the failure of concrete piers at Long Beach, Cal., I wish to make one suggestion which I have not seen referred to. It is, of course, entirely possible to build good, substantial piers under water if proper care is taken to have the forms tight and the concrete properly mixed but I observe one point about the construction of these piers that I think is most objectionable. Wooden piles were first driven and the concrete formed around these piles. I have had some experience in embedding wood in concrete work. This is a most unwise thing to attempt, as I have found that while the concrete is in process of setting the wood, by absorbing moisture, begins to swell and in every case where I have seen wood embedded in concrete I have found that the concrete was badly ruptured. This alone, in my opinion, would account for the failure of the piers at Long Beach. I have never before seen this subject referred to, but my experience had led me to avoid with great care the embedding of any wood in concrete work.

Yours very truly,

C. G. Rupert.

Wilmington, Del., Aug. 5, 1910.

Another Westerner's View of the National Conservation Movement.

Sir: Mr. Johnston's letter in your issue of July 28, 1910, seems to be a very strong presentation of one attitude in regard to what is generally understood as conservation.

He is perfectly right in asking for a definition of conservation, and a few lines lower gives one that is accepted by many thinking people here in the West, i. e., prevention of waste. It is yet to be shown that it means purely and simply capitalization of public resources of the West. There is no reason why Wyoming, for instance, should pay tribute to the National Treasury when that tribute is derived from Wyoming's individual possessions, but as I understand the matter this tribute arises from public domain in which the Eastener as well as the Westerner has an actual and live interest.

In traveling around this Western country I often have come across those who are convinced, as Mr. Johnston seems to be, that the conservation movement has for its chief object the perpetuation of the administrative authority of certain Bureau Chiefs in Washington. I should consider it somewhat analogous to say that the police force of a large city was maintained to provide a living for its officers. There are a great many people out here who have found the safeguards of this so-called bureaucratic interference to be of much value. Several years ago I condemned as absolutely unsatisfactory a dam site on which it was proposed to erect a $900,000 dam. Later, some Eastern people became interested in the project and built enough of the dam to demonstrate that it was absolutely inadequate and a menace to those living below. A little official interference would have saved thousands of dollars, which have been worse than thrown away.

About a month ago I went to Washington to have an irrigation project, which had been condemned, reinstated. I spent two days in Washington, had a respectful hearing, and the matter was straightened out to the satisfaction of all concerned, this without the use of any political pull or personal influence.

It is my experience that the conservation movement interferes quite seriously with a great many hazardous promotions and consequently is making a goodly number of enemies. The matter of conserving possible power sites seems to be somewhat overdone, but it is difficult to prove that it is doing more harm than the uncontrolled promoting of power possibilities.

In this as in all other matters no hard and fast lines can be drawn, but it is just as well to have regulations too stringent as too lax, for it is much easier to properly modify the former conditions than the latter.

Yours truly,

Geo. M. Bacon, M. Am. Soc. C. E.

Salt Lake City, Utah, Aug. 2, 1910.

American and German Street Railway Service.

Sir: I read with a great deal of interest the editorial correspondence by C. W. B. in Engineering News of July 28, making comparisons between the street railway service in cities of Germany and of the United States. No one who has an opportunity to compare European institutions with those of America can fail to be impressed by the contrasts which your correspondent sets forth in such entertaining fashion; but while I am heartily in sympathy with his comments and criticism of our American ways, I think he has overlooked, or at least failed to emphasize, some important differences in the conditions which control the design and operation of the street railways under discussion.

In the first place, he seems hardly to give due weight to the influence on street-car design of the city with "straggling suburbs" as compared with the compact city like those of Germany. It may indeed be said without exaggeration that the street railway service of most American cities of large or moderate size is essentially a suburban rather than an urban service. Many of the car lines run to suburbs remote from the city and separated from it by long stretches of thinly populated country through which it is desirable to maintain a high speed with infrequent stops. Cars must be designed for the highest speed which will be required of them, and this fact, rather than the arbitrary "convenience of car-builders" may explain the comparatively high, heavy and inconvenient design of American cars. Again, American cities abound in steep grades which loaded cars are required to ascend at good speed. I doubt if the average German street-car *without a load* would be able to ascend the grades followed by the suburban lines leading out of Cincinnati; and many other cities, including Boston, New York, Montreal and San Francisco have grades almost as steep. On German roads the absence of steep grades is not less striking than the smoothness of the track, and even in the very hilly cities, such as Heidelberg, the street cars follow routes which are substantially level. The German cars operate largely within densely populated sections and need not be capable of speeds higher than are suitable for city streets. These requirements of power and speed permit the common use of small, light cars, and also of trailers with their attendant advantages.

Smoothness and silence of operation is promoted by one feature of design common on European cars, but never used in this country, so far as I am aware; this is the *bow trolley*, which takes the place of the noisy, buzzing wheel. It consists of a curved strip of metal which bears against the under side of the overhead wire, making sufficient contact to carry the current. The length of the bow is sufficient to insure some part of it being always in contact with the wire in spite of the lateral displacements to which the car is subject. I surmise that this device would not be adapted to carry a large current, and of course it couldn't be used at all with a double overhead wire, such as we have in Cincinnati.

Another admirable idea put into practice on many European street-car systems is that of *numbering the routes* instead of placarding the car with the names of its destination and of the most important places on its route. According to this system, each car bears as an identifying mark a large number which indicates the route which the car traverses. Maps, easily obtainable, show the routes corresponding to the various numbers, so that a stranger, even if he is ignorant of the language, has no difficulty in getting the right car. Many of the legends on our street cars are hopelessly baffling to the stranger, and Boston is one of the worst offenders, owing to the extreme complication of its system. Whenever I visit Boston, I am impressed anew with the truth of the saying that "Boston culture consists in knowing which car to take!"

Your correspondent does not take up the question of compensation paid to conductors and others, but I think we may fairly assume that they are not as well paid as the men who do corresponding work in this country. In Germany it is not uncommon for a passenger paying two or more fares to add an extra five pfennigs for the conductor, which the latter accepts with obsequious thanks. It is almost inconceivable that a passenger on an American street car should offer the conductor an extra cent as a "gratuity" or that if offered it should be accepted, or regarded otherwise than as an affront. It is not an uncommon sight to see women tending street-car switches in German cities, and I suppose they receive even less than the men—and no gratuities! All this of course helps to keep running expenses low.

These considerations, in addition to those advanced by your correspondent, may in part explain why we who patronize the street-cars receive so much less for our money at home than in Germany.

Arthur H. Morse.

2305 Nelson Ave., Cincinnati, Ohio, Aug. 1, 1910.

Other Elements Than Forestation Which Affect Stream Flow.

Sir: I note with considerable interest, in the correspondence column of your issue of June 30, 1910, a communication from Farley Gannett, Engineer to the Water Supply Commission of Pennsylvania, regarding the conclusions which can be drawn as to run-off from forested and barren areas by use of stream-gaging data. It seems to me that Mr. Gannett has emphasized a very important matter in connection with such studies when he says

that conditions other than the presence or absence of forests affect the character of the run-off of streams; and it should be remembered that some of these influ-

ences may work on either side and attain considerable importance.

There have been several instances in recent engineering literature and discussions on this subject where the importance of these factors has been overlooked. An example which has come to my attention because of a recent personal examination of the drainage areas involved, occurs in the discussion of the paper which Col. H. M. Chittenden presented to the American Society of Civil Engineers at the meeting of Nov. 4, 1908, entitled "Forests and Reservoirs in Their Relation to Stream Flow." Messrs. Leffingwell and Strong contributed to this discussion a very clear analysis of run-off conditions, during the years 1904 to 1906, inclusive, for the drainage areas of Merced, King, Kern and Owens rivers—streams which have their sources in the southern Sierra Nevada Mts. of California. They show that the fluctuations of flow are greatest on Kings and Merced Rivers which have the greatest forest cover, and are least on Owens River, which has the least forest cover, while Kern River occupies an intermediate place, both as regards stream fluctuation and forest cover. They go no further in their search for the cause of these peculiarities of stream flow, than to observe that the area of forest growth seems to be directly proportional to the amount of fluctuation in stream flow.

A field examination of the drainage areas of these rivers, however, indicates other reasons for the irregular flow of the Merced and Kings rivers and the more regular flow of Owens River—namely, differences in the topography and surface cover of the areas. The former streams both drain portions of the rough and precipitous western slope of the Sierra. The upper portion of their drainage areas have a bare granite formation broken by deep canyons and inaccessible domes and peaks polished smooth by glacial action. The middle portions are well timbered and there is a thin covering of soil and forest litter over the granite. The topography of this region, while not so rugged, is yet characterized by steep slopes. The timber growth extends down into the foothills where the topography is similar to that of the middle regions, but on a smaller scale.

The Owens River above the Round Valley gaging station drains not only a portion of the precipitous eastern slope of the Sierra, but also a considerable area of elevated plateau and desert valley, and also the west slope of a desert mountain range. The total area drained is about 450 sq. mi., of which only 23% is a high mountain region comparable in topography, surface conditions and precipitation to the upper portions of the Kings and Merced River areas. This high mountain area supplies about 60% of the total surface yield from the drainage basin. Of the remainder, the elevated plateau region comprises 31½ of the whole area. It has a rolling hill topography and supports a scattering growth of Jeffrey pine, showing that the depth of precipitation is at least 20 ins. per annum and in all probability greater. This region is covered with a deep surface mantle of loose volcanic ash and pumice which is noticeably lacking in geologically recent drainage channels, and in whose depressions are numerous regularly flowing springs. These facts show that precipitation upon this plateau area is practically all absorbed and its rate of run-off regulated by an agency other than the forests. The lower mountain slopes and desert valley floor make up 30% of the area and the desert mountain drainage 16%. Practically all of the small precipitation upon these areas is absorbed by the porous gravel and sandy formation of the valley fill.

Furthermore, the streams which drain the high mountain areas to the west must cross these porous formations on their way to the main river channel and there lose a portion of their flow by seepage.

Regardless of the forest cover, therefore, the topography and surface conditions of 77% of the Owens River drainage area are extremely favorable to the absorption, not only of the precipitation but also the flowing streams upon its surface; whereas conditions are extremely unfavorable for such absorption on the other streams considered. The forests of the Merced and Kings River basins help to a certain extent to equalize the flow of these streams, but not as effectively as does the porous surface mantle of the gently sloping Owens River basin. The comparison of these rivers is, therefore, not a fair one and conclusions drawn from such comparisons are liable to lead the engineer astray unless all the circumstances are known.

In a subject of such far-reaching importance, there should be a realization among engineers of the relative values of all elements which control the observed results and it is believed that engineering discussions should give more attention to the broader aspects of fluctuations in stream flow.

Charles H. Lee, Jun. Am. Soc. C. E.
Assistant Engineer Los Angeles Aqueduct.
Independence, Cal., July 12, 1910.

Dike at Herring River, Wellfleet, Mass.: Mosquito Extermination Work.

By FRANK W. HODGDON.*

The township of Wellfleet, on Cape Cod., Mass., with a population of about 1,000, has an area of about 20.8 sq. mi. A large proportion of this is salt marsh which, up to the last 50 years, was very valuable to the farmers, the hay cut there being used as feed and bedding for cattle and other live stock. These marshes were then well drained, the ditches kept open and in good condition by the owners of the property. With the advent of railroads it became more economical to purchase better fodder, brought from inland, and, as the population began to drift towards the cities, agriculture declined. The salt marshes were given very little care and the ditches were allowed to fill up. Soon the town was noted for the large number of mosquitoes found there; the summer hotel, built on a wharf at the head of the harbor, was closed for two seasons on account of the pest.

In 1904 the town started to abolish the pest by draining the marshes and oiling the stagnant pools. In 1905 the advice of the American Mosquito Extermination Society and the U. S. Department of Agriculture was sought and the locality was visited and examined by Mr. Henry Clay Weeks, the secretary of the society, and Mr. Elwood Mead, Chief of the Irrigation & Drainage Investigations of the U. S. Department of Agriculture. They found that the largest marshes were those drained by the Herring River and recommended that the river be diked near its mouth to exclude tide water and that the marshes be then ditched and drained, thereby removing the conditions favorable to the propagation of the mosquito and making large areas of fertile land suitable for raising crops.

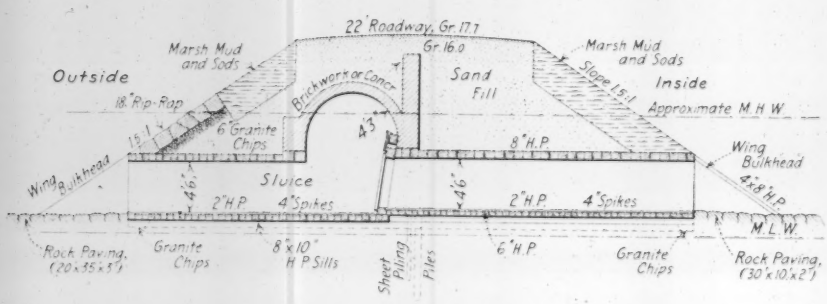
Mr. Channing Howard, of the firm of Whitman & Howard, Civil Engineers, Boston, was employed to make the necessary plans for building the dike. He found that there were about 1,100 acres of salt marsh tributary to the river and that a dike about 900 ft. long would be required at the mouth of the river to exclude the tide water, at an estimated cost of $16,000.

In 1907 the Commonwealth of Massachusetts made an appropriation of $10,000 towards the cost of building the dike and authorized the town to appropriate an equal sum. This was promptly done. The legislative act provided that the work should be done by its Board of Harbor and Land Commissioners. The Board employed Mr. Howard, who had made the preliminary plans to carry out the work under the supervision and direction of the writer, its chief engineer. Owing to legal delays the work was not commenced until the summer of 1908 and was completed late in 1909.

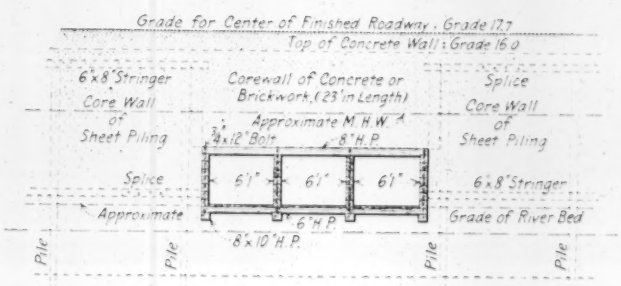
The dike is about 900 ft. long on top; the length between the marsh banks is about 500 ft. It is 22 ft. wide on top, at grade 17 ft. above mean low water; the average range of tide is about 10 ft. and the bed of the stream at the dike is about 1 ft. above mean low water. The side slopes are 1 on 1½; it has through it a sluiceway with three openings, each 4½ × 6 ft.; two of these are closed by automatic tide gates and the other by a stop gate. (See accompanying sections.)

The dike is an embankment of sand, taken from pits in the hills at each end of the dike, with a line of 4-in. splined spruce sheeting on the center line throughout its length driven about 6 ft. into the river bed, which is also of sand, and extending nearly to the top of the dike.

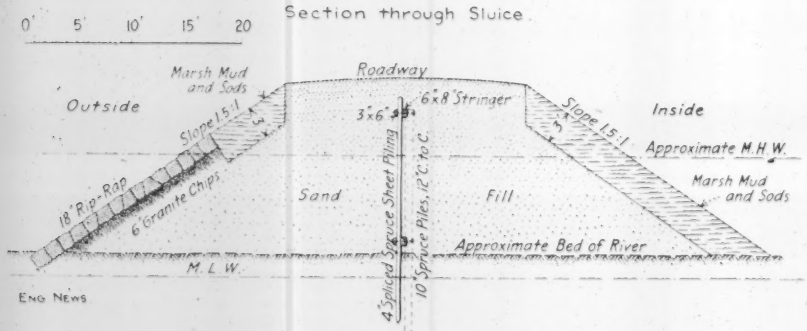
The face of the embankment on the up-stream



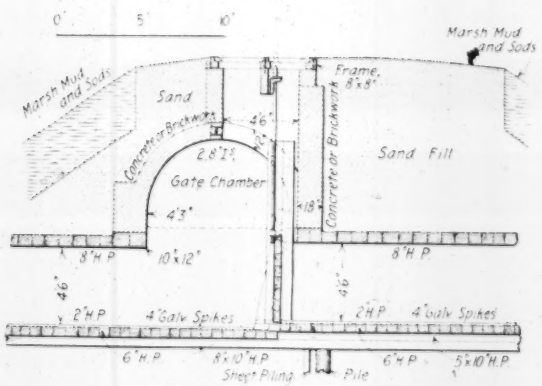
Section through Sluice.



Longitudinal Section of Sluice.



Typical Section of Dike.



Gate Chamber Details Enlarged

SECTIONS OF DIKE AND DETAILS OF SLUICE AND GATE CHAMBER, HERRING RIVER, WELLFLEET, MASS.

*Chief Engineer, Board of Harbor and Land Commissioners, State House, Boston, Mass.

side is protected by a coating of marsh-sods 3 ft. thick and on the down-stream side between the marsh banks from the bed of the stream to 1 ft. above mean high water by a coat of stone chips faced by a paving of granite quarry grout; the whole is about 2 ft. thick. The balance of the down-stream side is covered with marsh sods like the up-stream face.

The top of the dike is surfaced with a mixture of fine sand and soil which was found under the marsh sods. This binds together and makes a fair roadway for light teaming. The top of the dike is to be used as a road to reach areas which will be fine locations for summer residences if the mosquito pest is removed.

The sluices are built of long-leaf Georgia pine with bottom, sides and top 8 ins. thick. Over and in front of the gates is a chamber covered with a concrete arch through which is a manhole over the stop gate. The gates are 3¼ ins. thick, of long-leaf pine, bolted with Tobin bronze bolts. The tide gates are each hung with three cast-iron link hinges, with bronze pins, and the stop gate is raised and lowered by a Tobin bronze screw operated by a crank at the top of the dike. The floor of the sluice is about 2 ft. above mean low water and the surface of the water in the pond above the dike varies from 12 to 18 ins. above the floor of the sluice.

The two ends of the dike and the sluiceways were built in the fall of 1908 and the work was suspended for the winter. The dike was completed in the summer and fall of 1909. The closure was made at low tide during a course of neap tides. The method adopted was as follows: After building out from both ends until a gap of about 100 ft. remained, the sheeting across the gap was driven and cut off as soon as driven at about 18 ins. above the river bottom at the level of one of the stringers used as a frame for guiding it. The pieces sawed off were saved to be replaced and spiked in place when the closure was made. Then the river bottom on both sides was protected with sand bags. The frame for guiding the sheeting was then strengthened by additional piles and stringers and was braced by wire guy ropes from the heads of the piles to other piles and heaps of quarry grout placed about 100 ft. above and below the center of the dike.

At low tide on the day selected the pieces of the sheeting which had been cut off and saved were replaced and spiked in position, closing the gap before the tide rose against it. Two gangs of four men each were employed and finished just as the tide arose against the sheeting.

The placing of the sand was at once begun but it was nearly two weeks before the embankment was filled across the gap. The sand filling below high tide level was either dumped into the water or was covered by the tide soon after it was deposited and very little attempt was made to ram or otherwise compact it. It was mostly dumped from a trestle at about the level of the top of the dike from automatic side-dumping cars which carried about 3 cu. yds. each. The track was laid so that the cars ran out from the pit by gravity and were pushed back on the level part of the track by two men and up the grade into the pit by a rope and hoisting engine.

The contract price for the work was $16,250. Thomas & Connor, of Middleboro, Mass., were the contractors.

At the present time the town is engaged in deepening and straightening the main waterways and ditches and preparing for the complete drainage of the whole marsh.

STEEL BOILER TUBES for locomotives have been found unsatisfactory on the Cape Government Railways, of South Africa, apparently owing to the bad quality of the water. Mr. H. Beatty, Chief Locomotive Superintendent, in his report for 1909, makes the following statement:

There was a regrettable increase in the number of engine failures last year, as compared with 1908, due to boiler trouble. The solid-drawn steel tubes which have been largely substituted for the brass and charcoal-iron tubes have proved very unreliable and short lived. The steel in these tubes appears to be of excellent quality, and will stand any ordinary test, but it will not stand the trying conditions to which locomotive boiler tubes are exposed in this country. Charcoal-iron lap-welded tubes are now being gradually substituted for steel tubes.

A Series of Notable Reports on Sewage Disposal by Dilution at Rochester, N. Y.

The City of Rochester, N. Y., in conjunction with the State Department of Health, has raised some questions regarding the rational disposal of sewage into large bodies of water which are of world-wide significance. The answers to these questions bid fair to mark an epoch in sewage disposal by establishing more firmly than ever before the fundamental principle that sewage disposal by dilution or into water may be as legitimate as sewage disposal on land.

For a number of years past relief from sewage pollution in the Genesee River below the City of Rochester has been a pressing question. In 1907, Mr. Emil Kuichling, M. Am. Soc. C. E., Consulting Engineer of New York City, submitted plans for intercepting sewers to divert the sewage from the river to a point near Lake Ontario, where he recommended the establishment of sedimentation and screening works for the removal of a portion of the suspended matter prior to the final discharge of sewage into deep water in Lake Ontario, thousands of feet from the shore. An exhaustive study of local conditions led Mr. Kuichling to conclude that no public water-supply would be endangered by this means of disposal and that it would result in no nuisance of any sort. The settling basins and screens were not, of course, relied upon to give any marked degree of purification, almost absolute reliance being placed upon the final destruction of all harmful matter contained in the sewage by dilution, dispersion and digestion through the agency of the waters of the lake.

For reasons which we cannot explain, a considerable portion of the daily press of Rochester showed far more concern than one would naturally expect over this proposed method of sewage disposal. A number of local papers seemed to unite quite consistently in demanding a relatively high degree of purification.

After considerable delay Mr. Kuichling's plans for sewage disposal were presented to the State Department of Health for approval by Mr. E. A. Fisher, M. Am. Soc. C. E., City Engineer of Rochester. The plans, it should be stated, had already been approved not only by Mr. Fisher himself but also by Messrs. Rudolph Hering, M. Am. Soc. C. E., of New York City, and Mr. George H. Benzenberg, M. Am. Soc. C. E., of Milwaukee.

Mr. Kuichling had made a very strong supplementary report in which he summarized with remarkable clearness and conciseness the sewage disposal situation at Rochester in relation to possible lake pollution and also the general status of sewage purification at the present day. Presumably, in view of both the strong contentions in the local press for a higher degree of purification and because of his own frequent and strong expressions of opinion to the effect that the discharge of untreated, or relatively untreated sewage into the waters of the lake ought to be stopped, Dr. Eugene H. Porter, Commissioner of Health of the State of New York, decided to refer the Rochester sewage disposal plans not only to his engineering department, as usual, but also to three eminent engineers each of whom has had much experience in sewage disposal and allied matters. The engineers selected were Messrs. Allen Hazen, M. Am. Soc. C. E., of New York City; X. H. Goodnough, M. Am. Soc. C. E., Chief Engineer of the Massachusetts State Board of Health, and F. Herbert Snow, M. Am. Soc. C. E., Chief Engineer of the Pennsylvania State Department of Health. Each of these engineers submitted to Dr. Porter a report in which he answered a number of specific questions addressed in common to each. After considering these reports and also the lengthy and detailed reports and the final recommendations of Mr. Theodore Horton, M. Am. Soc. C. E., Chief Engineer of the New York State Department of Health, Commissioner Porter returned the Rochester plans to Mr. Fisher without his approval, but with an endorsement of recommendations of changes advised by Mr. Horton.

This action on the part of Commissioner Porter has been represented in press dispatches sent over the country as a virtual turning down of Mr. Kuichling's plans and as a demand for material changes and a considerably higher degree of purification before the Department would permit Rochester to discharge its sewage into Lake Ontario. As a matter of fact, the changes advised by Mr. Horton and insisted on by Commissioner Porter are relatively minor, and have absolutely no relation whatever to the broad general plan of sewage disposal by dilution and dispersion. So far as the works to be constructed at present are concerned, it is merely demanded that the six small settling tanks (each 57 ft. long, 16 ft. wide at the top and 6 ft. at the bottom) which are really little more than grit chambers, should be doubled in capacity and provided with skimming boards for remaining grease, and that provision should be made for a future possible multiple discharge, instead of a discharge at a single point, of sewage into the lake and for a possible future extension of the outlet sewer into the lake.

No change whatever was advised by Mr. Hazen. Mr. Goodnough suggested no enlargement of the tanks or increase in any way in the amount of purification affected, but did suggest provision for possible future extension of the outlet or the provision of "two or more outlets should occasion require in the future." Mr. Snow advised that it would be "well to consider the advisability of increasing at the outset the size of the sedimentation tanks." He also suggested that the State Department of Health maintain control of the situation by giving conditional approval of the plans, so worded that further purification could be called for in the future.

The Rochester problem, both in itself and as handled by the various engineers whose names we have mentioned, is so interesting and instructive and the final conclusions reached seem to us so important that we propose to put on record considerable portions of the reports mentioned. We should like to make very extended extracts from Mr. Kuichling's supplementary report, already mentioned, but inasmuch as that report is now in print and the others are not, and in view of the limitations upon our space, we shall be compelled to present an outline of Mr. Kuichling's plans in the course of our abstract of Mr. Horton's report. This abstract, or at least a portion of it, will be given first to aid in a clear understanding of the other reports. We shall then give Mr. Hazen's report nearly in full, as it embodies a more comprehensive review of the whole subject than do the reports by Messrs. Goodnough and Snow.

The two last-named reports will be presented in part, omitting those portions which refer more particularly to the effect of diverting the sewage from the Genesee River, as compared with leaving it in that stream; that is, our extracts from the reports of Messrs. Goodnough and Snow will include those portions only which deal with the sufficiency of the proposed sewage works and the effect of the effluent of Lake Ontario.

Mr. Horton's Report on the General Problem of Sewage Disposal at Rochester, with Outline of Mr. Kuichling's Plan.

Mr. Horton states that the northerly boundary of the City of Rochester is within about five miles of its southerly boundary, and within some eleven miles of the shore of Lake Ontario. The population of the city increased from approximately 82,000 in 1875 to 182,000 in 1905. Mr. Kuichling estimated that in 1925 the population of the city would be 260,000 and that an additional population of 15,000 in the towns of Gates and Greece adjoining the city on the west line would probably be ultimately included within the city limits. Accordingly, he based his plans upon a future population of 275,000. Mr. Horton forecasts the population ten years later than Mr. Kuichling, placing it at 325,000 in 1935.

Omitting 1,313 acres of parks, cemeteries, rivers, etc., and 794 acres in an annexed district (formerly Brighton village) which has a separate sewerage system, the discharge from which it is proposed to treat in independent works, the area tributary to the proposed intercepting sewer is 10,520 acres within the city limits and enough

outside to bring the total up to abont 16,000 acres. Mention may be made in passing of a possible future supplementary water-supply from Lake Ontario. With the exception of the sewers in the Brighton district, practically all Rochester is served by combined sewers. There are eight outfalls discharging through downtakes into the Genesee River. Of these two are above or north of the upper falls, and the remaining six between the upper falls and the northerly city line.

The Genesee River has a total drainage area of about 2,500 sq. miles. It has an average fall of 14 ft. per mile from its source to its mouth and drops a total of 264 ft. within the city of Rochester. Of the three falls within the city limits, the upper, 100 ft. in height, is located at about the middle point of the city, and the other, two, at heights of 30 and 100 ft., respectively, are 1¼ and 1½ miles northerly of the upper falls.

The minimum ordinary monthly flow of the river at Rochester is about 300 cu. ft. per sec., or .127 sec. ft. per sq. mile of drainage area. An extreme dry-weather flow of not over 200 cu. ft. per sec. or about .085 sec. ft. per sq. mile has been recorded. At 300 cu. ft. per sec., the river flow is equivalent to 1.5 cu. ft. per sec. per 1,000 for the present population, and slightly below 1 cu. ft. per sec. per 1,000 for the estimated population of 325,000 in 1935.

The plans before the State Department of Health for approval included intercepting and main trunk sewers, of a total length of about 7½ miles and with an approximate maximum capacity of 100,000,000 gals. per day. This outlet would terminate in detritus tanks about ½-mile south of Lake Ontario, and abont 3 miles north of the north line of the city. The sewer is designed for a water consumption of 100 gals. per capita per day, and on the basis of the present population would give a total outlet sewer capacity of 500 gals. This would diminish to 360 gals. per capita for 275,000 people in 1925, and 308 gals. for 325,000 people in 1935. It is assumed that during portions of the year the average daily flow of domestic sewage would be from 125 to 150 gals. per capita, leaving 150 to 175 gals. per capital of storm water capacity when the population reaches 325,000. The outfall sewer from the tanks and screening apparatus may be described in Mr. Horton's own language as follows:

> The outfall sewer leading from the sewage disposal plant will consist of a steel pipe 5 ft. in diameter and about 9,400 ft. long, 7,000 of which will be laid in a trench on the bottom of the lake. The last 50 ft. of the 5-ft. steel outfall sewer terminates at a crib 50 × 30 ft. in plan and 20 ft. deep, designed to protect the end of the pipe from injury by ships, anchors, etc. The bottom of this crib will thus be some 8 ft. below the bed of the lake and 58 ft. below the water surface of the lake, and will be filled with stone to hold the crib and enclosed outlet section of the steel pipe firmly in place. This outfall sewer will terminate at the crib in a vertical reversed curve which will bring the invert of the end of the pipe about 5 ft. above the lake bottom and about 45 ft. below the surface of the water.
>
> The sewage disposal works comprise six detritus tanks, each provided with two screens, one a flat iron bar screen placed at the inlet end of each tank and the other a revolving screen placed in the outlet channel from each tank.
>
> The flow from the trunk sewer leading to the plant is to be carried by two diverging channels constructed in concrete across the ends of the six detritus tanks. From these two main channels, separate channels, 2½ ft. wide and 7 ft. deep, lead to each tank. At the entrance to each tank the bottom of each of these separate channels is raised about 2 ft. and two 24-in. pipes, one leading from each side of the channel, carry the flow from the lower elevation of the channel around to the quarter points of the end of each tank.
>
> About 5 ft. from the entrance end of the tank, a flat iron bar screen extends across the tank. This screen is set at an angle of 70° from the vertical and the lower edge rests on a concrete bench extending from the end of the tank 10 ft. below the top of the tank and 8 ft. below the flow line of the tank.
>
> Each tank is 57 ft. long, 16 ft. wide at the top and 6 ft. wide at the bottom and has a bottom slope of about 1 in. per ft. of length toward the sludge pipe inlet. The side walls are vertical for a depth of 4 ft. below the flow line (6 ft. below the top of tank) and the depth of flow in the tank ranges from 11 ft. near the outlet end to 14 ft. over the valve of the sludge pipe situated 12 ft. from the inlet end.
>
> An 18-in. sludge pipe, with hand-operated stop valve, leads from a point at the bottom of each tank on the center line and 12 ft. from the inlet end to a sludge sump built in the end wall of the tank, the bottom of this sump being 4 ft. below the bottom of the tank.
>
> The plans show a revolving screen in the outlet channel from each detritus tank. This channel is 6 ft. wide and the bottom is 4 ft. below the flow line, except for a curved depression of 18 ins. under the revolving screen. The revolving screen is placed with its axle 6 ft. from the detritus tank and consists of a pair of circular end frames, 12 ft. 8 ins. in diameter, connected by five radial blades of wire cloth, having approximately 1/12-in. meshes and extending across the channel. The screen is to rotate so that its blades revolve against the flow of sewage, and appliances are to be provided for automatically removing the materials caught and retained on these screens.
>
> The capacity of each tank is about 8,133 cu. ft. or 61,000 gals., giving a total capacity for the six tanks of 366,000 gals. The time of detention of sewage in the detritus tanks, on the basis of 100 gals. per capita daily from a population of 210,000 (slightly more than the present estimated population) is about 24½ minutes. On the same basis of sewage contribution per capita, the time of detention in the tanks of sewage from a population of 275,000, as estimated for 1925, will be 19 minutes and for a population of 325,000 estimated for 1935, the time of detention will be 16 minutes. Based on a daily flow of 100,000,000 gals., or the capacity of the lower section of the main trunk sewer, the period of detention in the detritus tanks, as proposed by the design, is about 5 minutes, and the average velocity of flow through the tanks will be about 1/6-ft. per sec.
>
> It is evident, therefore, that the time of detention in the detritus tanks during times of storm, when the flow in the trunk sewer approaches a rate of 100,000,000 gals. daily, will be only about 1/5 the time of detention which occurs during periods of no rainfall. When the flow in this trunk sewer would exceed 100,000,000 gals. per day as a result of storms, raw sewage will be discharged into the Genesee River, and the relative amount of such sewage overflow will depend largely upon the excess rainfall at such times.

Having outlined the Rochester plans under consideration and presented some of the governing conditions, as stated by Mr. Horton, we will next take up the reports of the consulting engineers, since, judging from their dates and the date of Mr. Horton's report, the final conclusions and recommendations of the latter were written with the reports of the consulting engineers before him.

It appears that Mr. Kuichling's plans and copies of his reports were submitted to the several engineers, together with a list of questions to which replies were requested. It also appears that the general subject was gone over with the several engineers, or at least two of them, by Mr. Horton personally.

Report of Mr. Allen Hazen.

After prefacing his report with some general statements, including one to the effect that he has taken up the subject "as you request, from the general standpoint only," Mr. Hazen proceeds by quoting each of the questions asked by Commissioner Porter and answering each question in turn. We give the whole of Mr. Hazen's report, except the general introductory statements, as follows:

Q—1. Will the system of intercepting sewers removing from the Genesee River the raw sewage of Rochester except during times of storm, eliminate practically all nuisance from the river in and below the City of Rochester?

A—1. The flow of the Genesee River, as set forth in Mr. Kuichling's report, is more than sufficient to receive and dilute all storm overflows, so that they will not produce nuisance in and along the river in and below the city.

Q—2. Will the overflow of sewage during storms after proposed plans are executed, produce any nuisance along the river in or below the city?

A—2. No nuisance will be produced by such overflows in or below the city.

Q—3. Will the effluent from the proposed sedimentation and screening plant, after discharge into lake 7,000 ft. from shore in 55 ft. of water, produce any nuisance in the lake at the point of discharge or beyond a very limited zone immediately surrounding such point of outlet?

A—3. It will not. I speak from observations of the discharge of sewage into various bodies of water, and especially into the Great Lakes, including the discharge of the sewage of the city of Toronto into Lake Ontario and into the relatively small harbor during the last two years.

Q—4. Will pollution affecting in any way the senses occur along the lake shore as a result of discharge of the effluent from the proposed sedimentation and screening plant, under adverse conditions of wind or wave action?

A—4. No pollution affecting in any way the senses along the lake shore as a result of the discharge of the effluent is to be reasonably anticipated, even under adverse conditions of wind and wave action.

Q—5. Will any chemical or biological traces of sewage ever be found so far distant from the outlet as along the shores of the lake?

A—5. I should say that ordinarily no chemical or biological traces of sewage could be detected at the lake shore, but there may be times when refined methods of research would show such traces. In that event they certainly would be traces rather than substantial quantities of material of practical significance.

Q—6. Will the sewage effluent from the proposed sedimentation and screening plant, discharged at a point 7,000 ft. from shore in 55 ft. of water result in less pollution along the shores of Lake Ontario, east or west of the mouth of the Genesee River, than now occurs from the raw sewage discharged into the Genesee River, and in turn into the lake at the mouth of the river?

A—6. This question involves a great many complicated conditions, and it is difficult, if not impossible, to take them all adequately into consideration on present evidence. It is my impression, after talking the matter over with Mr. Horton, reading the reports and studying the maps, that the greatest amount of pollution along the shores of Lake Ontario under present conditions takes place following, and as a result of, flood discharges in the Genesee River, which discharges carry the present city sewage to the lake without the sedimentation and partial purification which it otherwise has in the lower parts of the Genesee River, where the current is sluggish in dry times.

With the proposed arrangements storm overflows will be carried by floods in the Genesee River to the lake under the same conditions that sewage flows are now carried. For this purpose the storm overflows at such times may be taken as practically equivalent to the full flow of sewage under present conditions.

If I am right in assuming that the greatest pollution along the lake front results from these conditions, then the proposed conditions will be practically identical with the present conditions in this respect. There will be this difference, however, that under present conditions the sedimentation of the sewage in the channel of the Genesee River at low-water stages results in the formation of deposits which are flushed out by flood flows, and which deposits will not occur to the same extent, if at all, under the proposed conditions. This alternate deposition of sediment and flushing out of the accumulation by flood flows tends at the present time to minimize the pollution of the lake at low-water stages of the Genesee River and increase it at flood stages.

Aside from this, the greatest tendency to the pollution of the water along the shores of the lake, both under present and proposed conditions, will be brought about by strong inshore wind. Such a wind would hold the water from the Genesee River with the sewage, under present conditions, along the shore. Under proposed conditions it would tend to drive lake water mingled with sewage to the shore. The amount of dilution with lake water occurring by the natural processes of mixing and being driven through 7,000 ft. to the shore, would certainly exceed the amount of dilution in the Genesee River water, and to that extent any evidence of pollution along the shore would be reduced.

On taking into account both of these conditions as well as I can, I find that the pollution of the lake water along the shore, both under present and prospective conditions, will fluctuate through wide limits, depending upon conditions of river flow and wind over the lake. The fluctuations under the two conditions will not always be parallel, and at times, because of these fluctuations, the possibility of pollution at a particular point under the proposed arrangements may be greater than it would be under present conditions at the same time and point, but looking at the matter broadly the maximum amount of pollution occurring at times of flood flow in the Genesee River under the proposed conditions will not be greater, and will probably be somewhat less, than it now is, and the average amount of pollution will be less.

Q—7. Will any pollution from the discharge of effluent from proposed settling and screening plant reach the shores of Lake Ontario in amounts and under conditions that will injuriously affect bathing along these shores or appreciably menace the health of bathers?

A—7. It will not. Following the reasoning under Question 6, the average conditions will be better than at present. There is, of course, at least a theoretical risk in bathing under either present or proposed conditions, due principally to the possibility of the bathers swallowing slightly polluted water. This is a danger very widely distributed in waters used for bathing, and waters are habitually used in this way that would not be considered suitable for water-supply in their raw state. The question is an interesting one, but the danger in this case seems to be remote. So far as such danger might exist it would be very much less than the danger which exists in enclosed swimming pools, even

in those in which the water is changed with the greatest frequency.

Q—8. Will the organic matter remaining in the sewage effluent after treatment in the proposed sedimentation and screening plant be ultimately completely oxidized before any such organic matter has traveled any considerable distance from the outlet?—especially before it could travel as far distant as 7,000 ft., to the nearest shore of the lake?

A—8. The organic matter remaining in the sewage will undoubtedly be ultimately oxidized either completely or else reduced to an unappreciable and absolutely harmless residuum of stable material incapable of oxidation. A part of this oxidation will take place rapidly. Another part slowly. A strong inshore wind might drive water containing a small amount of sewage 7,000 ft. to the shore in a much shorter time than would be required for the complete oxidation of the organic matter. In this case extreme dilution rather than complete oxidation would be effective in rendering the matter harmless.

Q—9. Will the discharge of the effluent from the sedimentation and screening plant under the proposed conditions affect the potability of the filtered water-supply of Rochester and Ontario Water-works, west of the mouth of the Genesee River and some three miles from this proposed outlet?

(a)—more deleteriously than under existing conditions of discharge of raw sewage into the Genesee River?

(b)—in general to such an extent, assuming ordinary operations of the filter plant, so as to be a menace to this supply?

A—9. (a) The answer to this question follows directly the answer that has been already given to Question No. 6. The dry-weather flows of sewage which go through the intercepting sewer will be rendered practically harmless so far as this intake is concerned. Probably, also, the dry-weather flows of sewage, with present arrangements, are greatly reduced in infecting power by the slow passage through the lower reaches of the Genesee River.

The greatest danger to the water at the intake mentioned probably comes from flood conditions in the Genesee River. At present these floods carry all of the sewage then flowing, and in addition the accumulations of sewage mud scoured out of the lower reaches of the river. Under proposed conditions they will carry the storm overflows, which for this purpose may be taken as practically equivalent to all of the sewage, but the practical elimination of the sewage mud taken up from the river bed will be a distinct advantage.

The danger of infection of the water-supply from these flood flows seems to be so much greater than the danger of infection from the dry-weather flows, either discharged through the Genesee River or through the proposed outlet, that the conditions during flood periods practically overshadow all other conditions in importance.

I do not consider that the proposed plans will result in any great, or even material, improvement in the safety of the water-supply from the intake referred to, but whatever change there may be will tend to reduce the risk of its infection.

(b) A well-constructed and well-operated filter plant is certainly capable of producing thoroughly good and safe water from the water of Lake Ontario, taken at any reasonable distance from the points of discharge of sewage. I may mention the filter plant now being constructed at Toronto from our plans to purify the present supply obtained from the lake at a distance of three or four miles from the point where all the sewage of Toronto will be discharged after the works now under way are completed. It is proposed to treat the sewage at Toronto in the same way that is proposed for Rochester, namely, by screening and sedimentation for a very short period before discharge. The whole plan has been most carefully considered and the purification of the water is relied upon to remove any traces of sewage that there may be in the raw water with the proposed arrangements.

Q—10. Will any pollution derived from the discharge of the effluent of the proposed disposal works—

(a)—ever reach the water intake of the Oswego supply, taken from the lake some 30 miles distant, just west of the mouth of the Oswego River?

(b)—if it should ever reach the intake under favorable conditions of wind, would the pollution be

(1)—less in amount and frequency than would occur from pollution carried from the polluted Oswego River and the sewers of the City of Oswego?

(2)—in such amounts and with such frequency that, independent of other pollution, it would appreciably affect the potability of the Oswego supply?

A—10. (a) This seems too remote for any practical consideration. So far as I have been able to learn in study of the waters of the Great Lakes, extending over nearly 20 years, the only pollutions that have caused actual trouble have been those resulting from the discharge of sewage within, at most, four or five miles, and usually from sewage discharged within a much shorter distance of the intake. This statement applies to the open lakes, and not to rivers connected with the lakes, in which there are strong currents. In such currents, of course, pollution may be carried much further, as, for instance, in the Detroit, Niagara and St. Lawrence rivers. I have never had any reason whatever to believe that water was injuriously affected by the discharge of sewage at a distance of 50 miles in the open lake.

(b—1) If there should be pollution it would certainly be much less in amount and frequency than would occur from the pollution carried by the polluted Oswego River water.

(b—2) It would certainly not be present in amounts that would appreciably affect the potability of the Oswego supply.

Q—11. If the proposed plans are insufficient, should additional purification be accomplished—

(a) by removing danger to health by disinfection or sterilization?

(b) by increased oxidation or nitrification through biological filtrations?

(c) by double protection obtained by biological filtration and disinfection?

A—11. In my judgment the plan submitted is sufficient and neither of the two auxiliary procedures mentioned under sub-questions need be resorted to. The disinfection of sewage no doubt has its uses, but is is a somewhat difficult and experimental process at the present time. If it were carried out in this case its only use, so far as I can now see, would be to tend to protect the water taken by the Rochester & Lake Ontario Water Co. from pollution. This water I understand is filtered before use. To disinfect the Rochester sewage with this end in view would mean (1) treating a quantity of sewage probably ten times as great as the volume of water, and (2) treating sewage which is a difficult and expensive substance to disinfect, instead of treating the lake water taken at the filter plant, which is an ideally easy and cheap substance to disinfect. It would certainly cost ten times as much to disinfect a volume of sewage as a volume of water at the intake, and with the greater volume of sewage it would cost at least one hundred times as much to disinfect the Rochester sewage as it would to disinfect the water taken at the intake. The former would only protect the water from that part of the possible pollution which came from the dry-weather flow of the Rochester sewage, which is probably not the most dangerous part of the flow. The latter would tend to protect the water from pollutions of all kinds from whatever sources.

From every standpoint it is enormously cheaper and also more effective to treat the water than it is to try to protect the water by treating the sewage.

To treat the sewage by oxidation or nitrification through biological filtration on the shore of the lake before discharging it would be to attempt to effect by artificial processes, at great expense, results that will be accomplished in the lake without cost by the organisms that are in the lake water and that are introduced with the sewage with the aid of the supply of dissolved oxygen in the lake water present in amounts enormously greater than required for this purpose. To spend money to do in a crude and inefficient way on shore with resulting inconveniences and nuisances to property owners in the neighborhood that which otherwise will be freely done in the lake without expense and without nuisance is certainly a great and inexcusable waste of natural resources.

Q—12. In view of the fact that the Genesee River below Rochester will not be potable after the execution of the proposed plans, and can not be made so because of the pollution which must directly or indirectly reach the river during its course, should only such purification be required as will guarantee freedom from any nuisance or any effect upon the senses?

A—12. In my judgment such purification as will guarantee freedom from any nuisance or any effect upon the senses of the Genesee River below Rochester is all that is required. If further purification is demanded, substantial reason for such purification should be shown, the reason being commensurate with the added expense of securing the result. So far as I know no such reason exists in this case.

Q—13. Judged in the light of the broader problem of Great Lake pollution, and the establishing of a general policy concerning the requirement for sewage purification, in connection with not only the City of Rochester, but of other cities and municipalities along the entire Great Lake System, are the proposed plans in their present form, or a somewhat modified form, sufficient and appropriate; and in your opinion should they be approved by the Department, either unconditionally, or upon certain conditions, and what?

A—13. Lake Ontario, according to Chittenden, has an area of 7,450 sq. miles. Its maximum depth is over 700 ft. From Government soundings I compute its average depth to be about 290 ft. It contains approximately 60,000,000,000,000 cu. ft. or 450,000,000,000,000 gals., equal to more than 410 cu. miles of water.

The amount of water entering the lake through the Niagara River and all other tributaries and leaving it through the St. Lawrence averages about 270,000 cu. ft. per sec., or 168,000 million gallons per day.

This is 1,600 times as great a quantity as the capacity of the proposed sewer running full, and from 3,000 to 8,000 times as great as the average volume of sewage that may be reasonably anticipated in the next twenty years.

The lake holds as much water as flows through it in 7.34 years. In other words, on an average, any given particle of water remains in the lake over seven years before it goes down the St. Lawrence River.

It may be said that the general flow of the lake is from west to east, that Rochester is east of the middle of the lake, and that matter discharged at Rochester will require a correspondingly shorter time, say three years, more or less, to reach the St. Lawrence. There may be some force in this suggestion, but, on the other hand, with the great depth of the lake, the turn-over of the whole body of water in the lake twice a year, and the movements of water through wind action, there is undoubtedly such mixing that long before the three years required for the water to flow from Rochester to the outlet have expired parts of the water that entered at Rochester will be distributed throughout the lake from one end to the other.

The organic matter in the sewage from all the cities now discharging into the Great Lakes is first diluted and then oxidized and destroyed by natural agencies to such an extent that the methods of chemical analysis now in use are not sufficiently delicate to show an increase in organic matter in the water of the open lakes away from sewer outlets from all of this pollution in the Great Lakes at the present time.

The micro-organisms discharged with the sewage and which, from the standpoint of water-supply, are principally to be feared, rapidly die under conditions existing in the Great Lakes.

If they did not die, but remained permanently in the water their combined numbers would be sufficient so that they could be easily counted in the lake waters, but remaining as those waters do for years, exposed to light and air, and with the bacteria living but a short time, their numbers are so far reduced, except in the immediate neighborhood of the sewer outlets, that it may be doubted whether present methods of bacterial examination are sufficiently delicate to show any change in the character of the water in the open lakes if the discharge of all sewage were to be entirely stopped.

If it were possible to draw all the water from the lakes that is to be used for domestic purposes from points well out in the open, away from local pollution, there probably would be little reason to complain of the quality of the water so obtained.

Unfortunately there are engineering difficulties to placing water-works intakes in positions to secure water of this character. From the standpoint of the workmen it is not possible to place intakes in water of as great depth as would often be necessary, and even where the water is not so deep as to make the necessary extension impossible, from a financial standpoint it is often cheaper to purify the water than it is to extend the intake to a point where water of sufficiently good quality could be obtained.

The water actually taken by the cities on the Great Lakes is probably without exception subject to local pollutions to such an extent that the water obtained is substantially less pure than in the open lakes, and the engineering and financial considerations above mentioned make it impossible or impracticable to secure water of this quality.

The broad fact must therefore be recognized that the water in the open lakes is of much better quality than the water now drawn for water-supply, and better than can be reasonably reached by intakes. For this reason the purification of waters drawn from the Great Lakes has been undertaken in various cases, and I look for the gradual extension of methods of purification that are more or less complete to all such supplies.

Where, because of the nearness of the points of discharge of sewage to the intakes, pollution of water-supply takes place at the present time, and may take place in the future with increasing populations, treatment of the water before use is both very much cheaper and very much more efficient in producing the desired results than any treatment of the sewage can ever be.

I am clearly of the opinion that there are no considerations of general policy outside of the purely local conditions that make necessary or even desirable the addition of other processes providing for more complete purification or treatment of the sewage than is contemplated by the plan now proposed.

In the past, increasing knowledge of many matters has often resulted in revisions of the views held upon many matters. Other like changes may be reasonably anticipated in the future. It may be that new conditions, or new knowledge of old conditions, will modify the views now held upon these matters. If that should prove to be the case, and if evils grow out of arrangements where no evil can be now foreseen, it would seem reasonable to leave to the future the correction of such evils when they occur. Remedies which might now be proposed for such possible conditions would not be likely to be well directed or advantageous. Provisions now made can be modified and revised in the future when good reason for so doing is shown.

On present evidence I do not know of any evils that can grow out of the proposed discharge of sewage that in any way justify the expenditure of large sums of money for its disinfection or purification, further than proposed by the plan now submitted.

Respectfully submitted,

(Signed) Allen Hazen.

Report of Mr. X. H. Goodnough.

Mr. Goodnough's report is only about half the length of that by Mr. Hazen. We present only that portion of it which answers questions 11, 12 and 13 (see Mr. Hazen's report on pages 158 and 159), inasmuch as the chief points at issue relate to the discharge of partially purified sewage into Lake Ontario and not into the Genesee River itself. We quote as follows:

In answer to questions 11, 12 and 13, it seems to me that the discharge of sewage into Lake Ontario, as proposed, is likely to be a reasonable and unobjectionable method of disposing of the sewage of the City of Rochester, at least until the population becomes much greater than at the present time. The nearest water-supply is apparently as much as four miles distant across the current of the Genesee River and against the direction of the prevailing winds, and it is unlikely that organic matter would travel from the proposed outlet to the intake of the water-works. Reliance against danger of pollution of the water-supply by the Genesee River, or in any other possible way, is placed in this case upon a filtration plant, as in numerous other cases in this country, and a suitable filtration plant properly operated has been found to be a reliable protection against such danger.

While it is extremely unlikely that the discharge of sewage at the point proposed will have in any way a seriously objectionable effect upon the waters of the lake or upon the use of its shores as a summer resort for bathing, etc., it may be found desirable at some other time to extend the proposed outlet to a point further from the shore or to divide the flow of sewage and discharge it at two or more outlets instead of at one outlet as proposed; or it may be found desirable to provide two or more outlets and, while discharging all of the sewage at one point, change from time to time the point at which the sewage is discharged. It is evidently practicable, without serious difficulty under the proposed plan, to extend the outlet, divide the discharge or use different outlets alternately if desired, and since the intercepting system will not all be completed at once, there will be ample opportunity to note the effect of the discharge of sewage at this point in gradually increasing quantities, so that modifications in the outlet may be made if likely to be desirable in anticipation of any probable need of such changes.

It is unlikely that it will be necessary or desirable to treat the sewage either by disinfection or purification for a very long time in the future, if ever, and there appears to be no need to make provision for such treatment in the beginning. Sedimentation and subsequent thorough screening for the removal of suspended matters and matters likely to float in the water of the lake is an essential treatment under the circumstances, and so far as can be judged is likely to be adequate for present needs and very probably for a long time in the future. It is possible that some contingency may arise making disinfection or the purification of all or a part of the sewage desirable at some future time. Such an occurrence is unlikely, since a very considerable amount of pollution must in any case enter the lakes from the cities about them at all times, so that the prevention of the pollution of these waters is impracticable. The capacity of the lakes to absorb and dispose of sewage properly diffused in the water is no doubt very great.

I have assumed in this report that the sewage will be the ordinary domestic sewage of a city little affected by manufacturing wastes or by other liquid of such character as to be likely to have a materially modifying effect upon the general character of the sewage. If the sewage contained an excessive quantity of greasy or oily matters, the presence of the sewage in the water might be traceable by its color or by means of a "sleek" on the surface of the water for longer distances than in the case of ordinary sewage, and if materials likely to affect considerably the character of the sewage are ever discharged into the sewerage system, they may have an effect upon the outlet and make treatment necessary, at least to the extent of removing such effect. So far as I am informed, the sewage at the present time is similar in composition to that ordinarily discharged from cities and towns.

I would suggest that provision be made, so far as practicable, in the first construction of the works, for extending the outlet further from shore or into a greater depth of water, or providing two or more outlets should occasion require in future.

Respectfully submitted,
(Signed) X. H. Goodnough.

Report of Mr. F. Herbert Snow.

Mr. Snow's report is still briefer than that of Mr. Goodnough, many of the answers to the first ten questions being "Yes" or "No." Mr. Snow, like Mr. Goodnough, agreed essentially with the conclusions of Messrs. Hazen and Horton on the points raised by questions 1-10. Mr. Snow's answers to questions 11, 12 and 13 are as follows:

Q—11. (a, b, c) Approval of the proposed plans should be provisional and admit of additions and changes to the plant as required. Disinfection of the settled and screened sewage should be the first additional mode of sewage purification applied to the disposal method. Later, if further purification were demanded, some form of biological filtration should be applied, and if finally a highly purified effluent were required, this could be secured by combining the preliminary treatment now proposed with filtration and disinfection. The project under consideration is adapted to the application of these successive developments.

Q—12. More purification should be required than will guarantee freedom from any nuisance. The plan contemplates purification through the natural agencies of dilution and oxidation in the body of the lake where these agencies are not subject to regulation and control; consequently, if they do not prove wholly capable of safeguarding the public health under the conditions which obtain, then further purification should be accomplished by the addition of a more extended preliminary treatment of the raw sewage.

Q—13. American municipalities have limited financial resources with which to meet almost unlimited demands for expenditures. Undoubtedly the value to a community of health measures is being appreciated more now than ever and public works along these lines may very generally prevail at no distant date. Nevertheless, the question of relative benefits from expenditures of the public funds must guide both municipal and state authorities in determining any particular question of public works involving public health. A policy should be conservative as well as progressive to endure.

It would most certainly be better if no sewage whatsoever were discharged into the Genesee River or Lake Ontario within three miles of a point from which the lake water is drawn as a source of supply to the public. The menace now established may be reduced so that the risk to human life will be small. It is better to reduce this risk than by an impracticable policy to prevent any reduction whatsoever; but it would be a mistake to unconditionally approve the proposed plans in their present form or in a modified form. The supervising power whose consent must be secured in the first instance, should have a continuing supervising power, and if at any time in its opinion, the system of preliminary treatment of the sewage and of its disposal into the lake has become prejudicial to the public health, then the City of Rochester should forthwith adopt such remedial measures as the State Department of Health shall advise or approve.

In my opinion, it will be well to consider the advisability of increasing, at the outset, the size of the sedimentation tanks.

Yours truly,
(Signed) F. Herbert Snow.

Mr. Horton's Final Review of the Plans, together with Conclusions and Recommendations.

We now return to Mr. Horton's report, bearing in mind that we have already presented his outline of the proposed intercepting and disposal works. Mr. Horton introduces this portion of his report by proposing to inquire into the "adequacy and efficiency" of the proposed plans as regards not only the needs of Rochester but also "the general welfare of the other municipalities situated along Lake Ontario that may in any way be affected." He calls attention to the fact that the Rochester plans are the first submitted to the State Department of Health which involve the discharge of any considerable volume of sewage into Lake Ontario. In view of the size of the proposed works and the large population they are to serve, Mr. Horton states that "the case constitutes an important feature, if not the leading one, at this time." After considering in some detail the proposed diversion of dry weather sewage from the Genesee River, he concludes that, although if the sewerage system of Rochester were being constructd de novo, it would be advisable to exclude the storm overflow from the river, yet, under the circumstances, it seems impracticable to do this, especially as it is unlikely that any considerable local nuisance will be created.

Mr. Horton next reviews the general subject of sewage disposal in its relation to the Rochester problems.

He concludes that the following changes will take place following the discharge of the proposed Rochester effluent into Lake Ontario 7,000 ft. from shore in an approximate depth of 50 ft. of water:

(1) A settlement of a portion of the fine, suspended and possibly colloidal solids upon the bed of the lake around the outlet for a varying but limited distance, due to the relatively greater specific gravity resulting from a dilution with the lighter lake water and the lowering of temperature while passing through the outfall pipe.

(2) A general diffusion and dispersion of the portion of the liquid sewage through the lake waters surrounding the outfall due to currents induced,—

(a) By differences in specific gravity of the sewage and lake water; the sewage being, by reason of its dissolved matters, of greater specific gravity than lake water; but, owing to the relatively higher temperature which it may possess at times, due to unusual changes in temperature of lake water and to relative loss of heat of sewage passing through the outfall (which would vary at times according to its volume and the time consumed in passing through the outfall) lighter than lake water.

(b) Through wind action which at times will stir the lake to a considerable depth although this agitation may not ordinarily extend to the depth of the outfall pipe.

(c) By currents of lake water along and over the pipe line, in reverse direction to the flow of sewage in the pipe due to the heat of sewage transmitted through the pipe, and covering of earth, to the lake water immediately over the pipe line.

(d) Rising gas bubbles due to septic action of solids deposited around outfall.

(3) A gradual diffusion and dispersion, throughout the body of lake water surrounding the outfall, of the fine suspended and colloidal matter whose net specific gravity (i. e. the natural, corrected for changes due to temperature and dilution of sewage in lake water) is about equal to the mixture of lake water and sewage.

(4) A rising to the surface of fine suspended and colloidal matter whose net specific gravity (i. e. the natural, corected for changes due to temperature and dilution of sewage with lake water) is less than that of the mixture of lake water and sewage.

(5) A transporting of the sewage and any suspended matters which have diffused or risen to the surface of the lake from the outfall to varying distances therefrom as a result of natural lake currents or currents induced by wind action. This transportation, or travel, will be generally oscillatory, governed almost entirely by direction of the wind, since currents of translation through the lake are relatively insignificant and the distance of travel will depend upon the intensity and duration of wind from any one direction.

(6) A slow but progressive decomposition due to septic, or anaerobic bacterial action, of any solid materials deposited around the outfall.

(7) A slow but progressive oxidation of the liquid organic matter either contained in the sewage effluent as it is discharged from the outfall, or derived from a liquefaction of the solids surrounding the outlet as a result of anaerobic bacterial life in the presence of sufficient oxygen carried in the lake water and replenished continuously from the atmosphere above as it is exhausted.

(8) The consumption as food of the suspended organic matter, both living and dead, by small aquatic organisms which are, in turn, successively devoured by larger ones.

(9) A gradual destruction of the original bacterial and disease germs contained in the sewage resulting from adverse environment, antagonism of species, settlement upon bottom of lake and consumption as food by higher forms of living organisms.

Following this summary, Mr. Horton calls attention to the fact that the object of any method of sewage purification is "the removal of objectionable suspended matters, oxidation of the organic matters and the destruction of bacteria." This may be affected on land, but

it is accomplished more economically but no less positively nor, under favorable conditions, less completely, or perhaps less rapidly, when sewage is discharged into sufficiently large bodies of water charged, and replenished, with dissolved oxygen.

A little further on he states:

In the case before us of the discharge of a sewage partially clarified by settlement and screening into a vast body of pure water practically saturated with oxygen, with ample opportunity for replenishment as this dissolved oxygen is absorbed and utilized for the nitrification of the organic matter, we have *in principal*, and in relation to the local conditions which exist, a method of disposal that may be considered most favorable. That is, as to capacity, the method and disposal proposed will have no coarse suspended matter to carry offence and danger to distant shores through wind and wave action; the finer suspended and colloidal matters will be so minute that if deposited on the bottom of lake or outlet they will be readily disintegrated or hydrolized by septic action, or, if dispersed into the body of water around the outlet, will be attacked by the aerobic bacteria and even higher forms of life and be either nitrified or consumed as food; the outlet will be so far distant from shore that large quantities of oxygen will be supplied from the vast volumes of fresh lake water which will pass progressively or oscillate back and forth over the outfall, the spent dissolved oxygen carried by the lake waters being replenished by absorption from the air at the water surface.

The purification affected by this method will not be absolutely complete but will be sufficient

for the present, and the plans may make possible a higher degree of purification, if ever it becomes necessary.

The balance of Mr. Horton's report may be presented with sufficient fullness in his own summary, which we give below, followed by his final conclusions and recommendations. The recommendations we have printed in italics, for the sake of emphasis. We now quote the concluding part of the report s follows:

To summarize briefly my opinions and conclusions concerning these plans, following a careful examination and study of them, I would state:

(1) That the proposed system of intercepting and outfall sewers will remove from the Genesee River practically all of the sewage now discharged into this river by the City of Rochester at all times, except during heavy rainfalls when the sewage will be discharged through overflows in a highly diluted state.

(2) That the diversion of this sewage will remove practically all offence and nuisance along the river in and below the city and along the shores of Lake Ontario near the outlet of the river.

(3) That during heavy rainfalls when overflowing of sewage will occur, the dilution of the sewage will be so great as to prevent any appreciable nuisance in and along the river below the points of overflow.

(4) That whereas the method of sewage disposal proposed, viz., by preliminary treatment in settling and screening tanks and final treatment by dilution, oxidation and digestion in Lake Ontario, is in principle a suitable and appropriate one for the City of Rochester, the plans are insufficient and inadequate as to capacity and important details and should be so modified and corrected as to provide:

(a) Settling tanks of twice the capacity shown by the plans.

(b) Skimming boards or other means for removing objectionable grease and oils.

(c) Branch connections near the end of the outfall sewer in the Lake to permit the flow to be divided and discharged at two or more outlets in the Lake whenever such provision may become necessary.

(d) Suitable means at the end of the outfall sewer which will permit of its being extended further out into the Lake, if, or whenever, such provision may become necessary.

(5) That the proposed method of preliminary treatment, if modifications in the plans are made in accordance with the above recommendations, will eliminate from the sewage all of the grosser, and a large percentage of the finer, suspended matters, which, on account of their relative insolubility and difficulty of segregation, and their offensive and dangerous nature, are easily transported by winds and induced surface currents, to considerable distances.

(6) That if the changes above recommended are made in the plans, the finer suspended solids remaining in the partially clarified effluent, after passing through the settling and screening tanks and after their discharge into Lake Ontario 7,000 ft. from shore in over 50 ft. of water, will be subject to combined action of sedimentation, dilution and dispersion to such an extent that no traces of sewage will be discernible to the senses along the shores of the lake or at any considerable distance from the outlet.

(7) That at times, under unfavorable conditions of wind and wave action, pollution from the effluent of the proposed settling and screening plant discharged into the lake 7,000 ft. from shore will even with modifications in plans above recommended, be carried to the intakes of the water-supplies of the Rochester and Ontario Water Company, and of the Village of Charlotte. This pollution will, on the whole, be much less in amount than occurs under existing conditions with the sewage of Rochester discharged into the river, and in turn into the lake near these intakes, and it will occur in such small amounts, at such infrequent intervals and be so diluted and attenuated, that with properly installed water purification plants, the health of the communities using those supplies will be amply protected against any danger of infection.

(8) That the possibility of any traces of sewage from the proposed outfall ever reaching the intake of the Oswego water supply, some 50 miles distant, is too remote for practical consideration. Even if traces were ever carried to this intake under unfavorable conditions they would be in such minute amounts and so attenuated as to have no appreciable effect on the public health of the citizens of Oswego, and entirely negligible as compared with the pollution of this water-supply by the polluted waters of Oswego River which now enters the lake only a short distance from said intake.

(9) That if it be found in the future, after these works have been put in operation and after practical opportunity has been afforded to observe and study the effects of the discharge of effluent from the proposed plan into the water of the lake, that the health or comfort of the people who reside along the shores of Lake Ontario, or who may use the water for drinking, bathing or other purposes, is in any way deleteriously affected, it will be easily possible, and within reasonable cost, to increase the degree of purification by providing increased or additional sedimentation, supplementary treatment in biological filters, or the application of disinfectants, or all.

In view of the foregoing conclusions, and of the expressed policy of this department of preventing the discharge of raw or insufficiently treated sewage into the waters of this state, I beg to recommend that these plans be disapproved in their present form, and that they be returned for corrections and modifications in accordance with the suggestions and recommendations outlined above.

Respectfully submitted,
Theodore Horton, Chief Engineer.

Report and Recommedations of Dr. Eugene H. Porter, Commissioner of Health.

The various reports from which we have quoted were dated as follows: Mr. Hazen's, June 17; Mr. Goodnough's, June 28; Mr. Snow's, June 22; Mr. Horton's, July 18. The final disposition of the whole matter for the present was made by Health Commissioner Porter in a letter to Mr. E. A. Fisher, M. Am. Soc. C. E., City Engineer of Rochester, dated July 26, 1910.

Dr. Porter, in his report, first mentions a public hearing of the plans which he gave in Rochester on June 9, 1910, and then states that "believing that the City of Rochester should have the best advice on this matter that the Department could give it" he submitted the matter of approving the plans "to three of the leading experts on sanitary engineering in this country," Messrs. Hazen, Goodnough and Snow. He then gives the questions placed before these engineers, as already stated in our reprint of Mr. Hazen's report. Next, Dr. Porter remarks that copies of the reports of the three experts and of Mr. Horton's report were forwarded to Mr. Fisher. The disapproval of the plans then follows, together with a statement of the changes required in order to make them satisfactory to the Department, and with a further statement that in any event the approval of the plans and modified to the satisfaction of the Department will be conditional on subsequent changes in modification, if such prove necessary.

We quote the latter part of Dr. Porter's letter as follows, calling attention to the fact that the statement of changes required is almost identical in wording with Mr. Horton's recommendations (a), (b), (c), (d), under his conclusion (4), given near the end of our reprint of the final part of his report:

After a careful consideration of the questions involved, I am unable to approve these plans in their present form and they are therefore returned to you without approval. The changes which will be required are fully outlined in the report and are, briefly, as follows:

(1) Settling tanks of twice the capacity shown by the plans.
(2) Skimming boards or other means for removing objectionable grease and oils.
(3) Branch connections near the end of the outfall sewer in the lake to permit the effluent to be divided and discharged at two or more outlets, whenever such provision may become necessary.
(4) Special means at the end of the outfall sewer which will permit of it being extended further out into the lake, if, or whenever, such a provision may become necessary.

In any event, the approval of these plans and permit granted in connection with them, will be conditional and will explicitly provide that if it be found after these works have been put in operation and after practical opportunity has been afforded to observe and study the effects of the discharge of effluent from the proposed plant into the waters of the lake, that the health or the comfort of the people who reside along the shores of Lake Ontario or who may use the water for drinking, bathing or other purposes, is in any way deleteriously affected, that there be such increase in the degree of purification by providing increased or additional sedimentation, supplemental treatment in biological filters, or other additional method of disposal as may be necessary to properly protect the public health and prevent a public nuisance.

As soon as the changes and modifications have been made in these plans in accordance with the recommendations contained in the report of our Chief Engineer, and they are returned to me for approval, they will again be promptly considered.

Very respectfully,
Eugene H. Porter,
Commissioner of Health.

The New Public Service Commission of Maryland.

After considerable agitation and some heated controversy the State of Maryland has fallen into line with a number of other states which have been progressive in the same matter, and has created a Public Service Commission with comprehensive powers and duties. The Act creating the Commission passed the last session of the Legislature and received the approval of the Governor on April 5, 1910.

The Commission created under this Act appears to be vested with control of every class of public service corporation in Maryland. Thus, under "common carrier" the Act specifies as within the control of the jurisdiction of the Commission:

All railroad corporations, street railroad corporations, express companies, car companies, sleeping car companies, freight companies, freight line companies, steamboat, power boat, and vessel boat, and ferry companies, canal companies, and all persons and associations of persons, whether incorporated or not, operating such agencies for public use in the conveyance of persons or property within this State, by land or by water, or both.

In a similar way "gas corporation" is so defined as to include all companies, or individuals, lessees, or receivers of property engaged in selling or distributing gas "for light, heat, fuel or power, or for any public use whatsoever." "Electrical corporation" is defined in substantially the same way. Telephone, telegraph, water, heat, and refrigerating companies are also specifically brought within the control of the Commission.

Broadly speaking, the Act seems designed to give the Commission control over all matters pertaining to character of service, rates charged, capitalization of companies of all sorts and conditions of public service corporations, or associations, or individuals which in any capacity supply the services indicated. In addition, franchise grants to new companies are made subject to the approval of the Commission.

The Commission consists of three members, appointed by the Governor, one of whom, to be named by the Governor, is to serve as chairman. No special qualifications for membership in the Commission are stipulated, except that the appointees must be qualified voters and not less than 25 years of age. There is, however, a blanket clause *disqualifying* anyone for the office of commissionership, officer or employee of the Commission

who holds any official relation to any common carrier, railroad corporations [and so on through the list of companies under the jurisdiction of the Commission], or who hold stocks or bonds therein, or who has any pecuniary interest therein.

The commissioners eventually will hold office for six years each, a new one being appointed at the end of each two years, and any commissioner is eligible for reappointment. Any commissioner may be removed by the Governor on charges for "inefficiency, neglect of duty, or misconduct in office" after due hearing.

The salaries of the commissioners are made $6,000 for the chairman and $5,000 for each of the other two members, but half the salary of the chairman and two-fifths that of the other commissioners are to be paid by the City of Baltimore to "as employees of said municipal corporation." It does not appear from the Act that the commissioners are to render any service to the City of Baltimore different from that to other portions of the state.

Although the Act makes specific provision for the appointment of a General Counsel to the Commission and various assistants, each at specified salaries, no provision whatever is made for engineering services other than what comes under the general clause of authorizing the employment of "such officers, clerks, * * * inspectors and employees as" the Commission "may deem necessary to carry out the provisions" of the Act. All appointees are to be selected by the Commission (except assistants to the General Counsel) but every appointment is subject to the approval of the Governor.

An interesting provision of the Act is one requiring the offices of the Commission to be open

for business from 8 a. m. to 9 p. m. "every day in the year," with one or more responsible persons in charge. An annual appropriation of $75,000 is made for the salaries and expenses of the Commission.

Provision is made for investigation by the Commission of "the cause of all accidents on any railroad or street railroad resulting in loss of life or injury to persons or property, and which in its judgment shall require investigation." All railroads and street railroads are required to notify the Commission of every accident occurring on their lines. Provision is made for a uniform system of railroad and street railroad accounting, conforming as nearly as may be to those of the Interstate Commerce Commission.

The authorization of the capitalization of franchises (at least those of common carriers) is prohibited by the Act.

Gas and electrical corporations are required to furnish "reasonably safe and adequate" service and facilities, the prices for which "shall be just and reasonable, and not more than allowed by law or by order of the Commission." Specific repeal is made of any existing legislation

prescribing or limiting the price at which any gas corporation, or electrical corporation, or any other corporation, subject to this Act may furnish, sell or dispose of its gas or electricity or other product, or utility . . . it being the intent of this Act [to give the Commission full control over all such rates].

Authority to investigate the quality of the services rendered by the various companies and to order improvements as are necessary to the public interest is given by the Act, as also power "to fix the standard illuminating power and purity of gas, * * * and the initial efficiency of incandescent lamps," etc. The Commission is also given "full and plenary power to value the plant, property, appurtenances, assets and franchises" of corporations under its control and to "prescribe uniform methods of keeping accounts" and records of all such companies. Complaints regarding the quality and price of gas and electricity may be made to the Commission by municipal authorities, or by 100 customers, whereupon the Commission must make an investigation and finding and issue orders accordingly.

It appears from the Act that the Commission is given similar jurisdiction over all the public-service corporations of the State engaged in supplying municipal needs.

Water Softening Plants of the Florida East Coast Railway.

By A. C. TOMLINSON.*

A branch line of the Florida East Coast Ry. (well known for its ocean viaduct extension to Key West) runs from Jacksonville, Fla., to East Mayport through the resorts of Pablo Beach and Atlantic Beach. As it is the only line serving these places and as East Mayport is the gateway for a heavy ocean freight traffic, the line has a dense freight movement. The locomotives used on this line are practically limited for their feed-water supply, to the water station at East Mayport. This water is taken from an artesian well and like a large number of other well waters along the lines of the Florida East Coast Ry., contains a large amount of scale-forming solids, principally carbonates and chlorides, that were taking a heavy toll each year from the company in increased coal consumption, in expensive repairs to boiler tubes, stay-bolts, and fireboxes, besides in dead-head locomotive mileage and in expense of maintaining extra locomotives in readiness to replace those sent to the shops for boiler repairs. With these conditions becoming more pronounced and serious each year, it was decided that East Mayport offered an excellent opportunity for installing a trial water-softening plant. To this end Mr. Geo. A. Miller, Superintendent of Motive Power and Machinery, made an exhaustive study of the merits of the various water-softening systems on the market and their individual adaptability to requirements of the Florida East Coast Ry. Their initial installation was of a softener having an hourly capacity of 8,000 gals. It was placed in regular operation early in Feb., 1906.

FIG. 1. LOCOMOTIVE WATER-SOFTENING PLANT OF THE FLORIDA EAST COAST RY., MAYPORT, FLA.

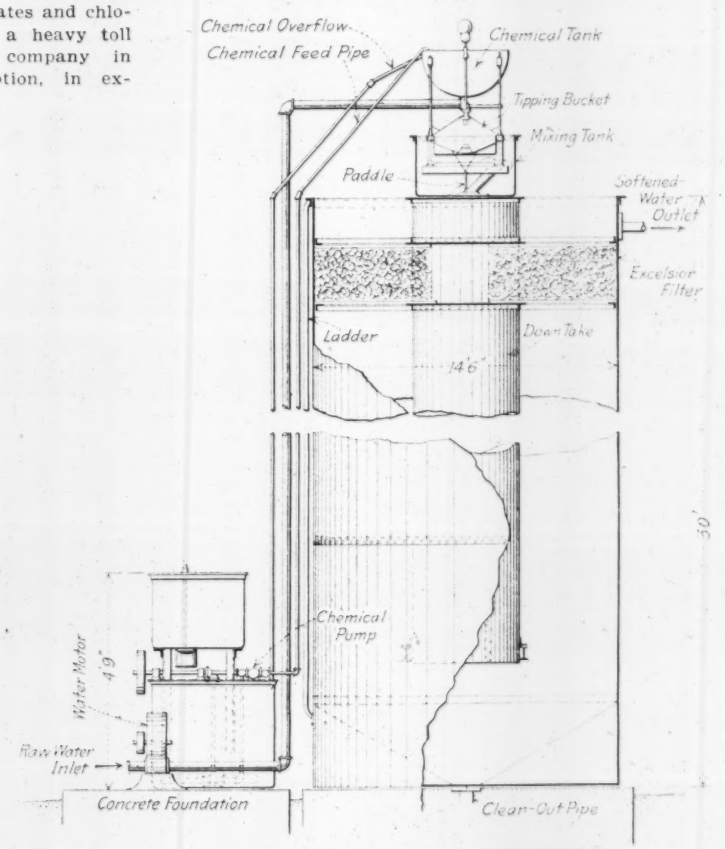


FIG. 2. ARRANGEMENT OF LOCOMOTIVE WATER-SOFTENING PLANTS, FLORIDA EAST COAST RY.

The water softener consisted of a steel settling tank 14½ ft. in diameter and 30 ft. high, with an iron stairway encircling it from ground level to top. In the top of the settling tank is a small rectangular tank containing the automatic measuring and mixing mechanism for adding the softening solution (lime and soda ash) to the crude water. As a part of this apparatus there is on top of the 30-ft. tower a semi-circular tank, always containing about 40 gals. of solution, in the bottom of which is a valve operated by a lever and cam system connected with a tilting bucket.

The tilting bucket is located just beneath the solution tank and has two separate compartments. The crude-water pipe has its discharge just above the tilting bucket so that the crude water flows into one compartment until reaching a certain level. Then the bucket becomes unbalanced, dumps and brings the other compartment under the crude-water discharge. The tilting is again caused in the reverse direction. This rocking works the cam and lever system of the chemical-feed valve so that the requisite chemicals are automatically added. At the same time the contents of the chemical tank are agitated.

The crude water, after receiving the proper amount of softening solution, is thoroughly stirred by a paddle attached to the tipping bucket. With a whirling motion, given to it to hasten the coagulation of precipitated impurities, the water passes through a downtake to the bottom of the settling tank, from which point it gradually rises to the top of the tank. For an added precaution, it is passed through an excelsior filter from which it flows by gravity to the storage tank.

A housing of neat design and suitable construction is located at the base of the settling tank. Here are located air-tight bins for a month's supply of chemicals, a chemical-mixing and lime-slaking tank, and a specially designed, positive-type of water motor that utilizes the crude water for furnishing all the power needed for mixing up the chemicals, for keeping the solution constantly stirred while the plant is in operation and running the pump that delivers the solution from a tank at ground level to the semi-circular one at the top of the softener. A double pipe line connects these two last-mentioned tanks so that the surplus solution required in keeping a constant level in the upper tank may continuously overflow to the lower tank while the plant is operating. The motor requires no free discharge and is operated only by the crude water going to the top of the softener for treatment. The excess water pressure required to operate the motor under full load is from 2½ to 3

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lbs.—equal to pumping the water an additional height of 6 ft. The interesting discovery was made that this well at East Mayport (which was a flowing well) showed a pressure of about 40 lbs., rather more than needed to operate the motor and to deliver the water to the top of the softener making it possible to operate the entire plant without steam pumps or other outside power of any kind.

The main solution tank on the ground level is designed to contain sufficient softening solution for 12 hours' continuous operation, making attendance oftener than once in that time, unnecessary. Opening the water valve at the motor places the entire plant in immediate and automatic operation.

This plant was given a thorough test both in efficacy and in economy of operation and a careful account was kept on the results accomplished by using purified water. As to efficacy, it was found that repeated analyses showed a practically unchanging quality of softened water and copies of typical analyses given in Table I. testify to the excellent degree to which the softening process is carried. From analysis No. 2 it is seen that the removal of scale-forming impurities is equal to the elimination of practically one and two-tenths tons of scale from the locomotive boilers each week, with the softener operating the full 24 hours. The analyses were made in the laboratories of the builder, as were practically all those for the Florida East Coast Ry.

TABLE I.—TYPICAL ANALYSES OF LOCOMOTIVE FEED WATER AT MAYPORT, FLA.

	No. 1, untreated water, grains per gal.	No. 2, water after treatment, grains per gal.
Total solids	18.09	10.80
Calcium carbonate	3.57	0.29
Calcium sulphate	5.35	....
Magnesium carbonate	4.16	1.08
Sodium carbonate	....	0.63
Sodium sulphate	0.70	6.26
Sodium chloride	2.43	2.43
CO_2, free	0.32	....
Iron and silicate	0.35	0.11
Incrusting solids	13.69	1.48*
Non-incrusting solids	3.13	9.32

*The sodium carbonate exists as free alkalinity, being the excess of that used to combine with the sulphates and chlorides of calcium and magnesium. The "non-incrusting solids" are necessarily increased when a raw water contains "hardness" in the form of sulphates or chlorides. "Incrusting solids" in treated water are harmless, provided they are transformed into mono-carbonates. It is impossible to remove, chemically, all the calcium and magnesium, as the mono-carbonates are slightly soluble.

These pleasing results convinced the Florida East Coast Ry. that further installations of softeners should be made as rapidly as possible at points where economy demanded, and orders were accordingly placed for additional plants. A standard capacity of 10,000 gals. per hour was adopted for all points except St. Augustine which, being a terminal point, required a plant having a capacity of 15,000 gals. per hr. As in the case of the initial installation made in 1906 at their East Mayport terminal, a careful watch was kept of the results following this further step toward the use of only purified water for locomotive service. Mr. G. A. Miller, after tabulating the results for which figures were procurable, issued a report which showed conclusively the advisability of additional water softening equipment and on which favorable action was taken. As this report gives some interesting figures and data on a subject that is deservedly gaining wider attention each year it is appended.

Mr. Miller opens his report by expressing an opinion that the installation of water softeners is justified when a sum equal to 5% on the investment, plus the extra cost of softening the water, can be saved in operation, and he then gives a table of water cost for a number of years (Table II.). Concerning the figures Mr. Miller stated:

TABLE II.—LOCOMOTIVE FEED-WATER COSTS, FLORIDA EAST COAST RY.

Fiscal year.	Cost.	Per cent. increase.	Per cent increase in locomotive mileage.
1905	$14,853	....	....
1906	16,085	8.2	5.13
1907	17,566	9.2	14.80
1908	21,912	24.7	11.60
1909	24,338	11.0	11.10

From Table II. it will be seen that the average increase for 1906 and 1907 is 8.7%; this increase appears to progress from year to year with the increase of locomotive mileage—more water requiring more fuel and more labor in the pumping. It will be noted that the installation of water softeners increased the total cost for water for the year 1908 over the previous year by 24.7%; this, less the 8.7% average yearly increase, leaves 16% increased cost due to treating water—equal to $2,897.05.

The last item should be added to interest charges, etc., on the investment, giving a total of $4,971 that the Transportation Department should save in the item of fuel, if softeners are justifiable.

In the last fiscal year, 2,161,053 locomotive miles were made. The yearly performance sheet shows that 20.5 miles were run on each ton of coal burned, a total coal consumption of 105,417 tons. At the time of placing softeners in operation the locomotive performance sheet showed an average of 20.2 miles to the ton of coal, therefore if the performance of the last fiscal year had been 20.2 miles per ton of coal a total of 106,982 tons would have been required, or an increase of 1565 tons. At the average cost of $3.30 per ton on tenders for fuel, this represents a saving of $5,164.50 resulting from the use of purified water.

The water softeners save enough coal to pay the interest on the cost of installation, the extra cost of treating the water and still leave a small surplus. It will be noted that the entire credit of this saving has been given to the Transportation Department. The burdens formerly imposed on the Mechanical Department have been shifted to the Transportation Department, where it properly belongs, and this department saves more than sufficient fuel to pay the cost of the investment and in addition procures the following: (1) Better train movement and less boiler failures on the road. (2) A suitable and assured water supply. (3) Heavier trains hauled for same or less expenditure in fuel.

The performance for fuel per mile run was as in Table III.:

TABLE III.—LOCOMOTIVE FUEL DATA, FLORIDA EAST COAST RY.

Fiscal year.	Purchase cost, cts. per mile.	Miles run per ton of coal.	Average number cars per train. Passenger.	Freight.
1905	15.51	21.9	5.9	13.2
1906	14.31	22.2	6.1	13.3
1907	16.33	20.2	5.9	12.3
1908	18.18	20.4	6.1	14.7
1909	15.70	20.5	6.2	20.5

The last good rain was in October, 1906; during 1907 the rainfall was so deficient that all ponds and dug wells dried up, hence the urgent need for a more reliable water-supply. As many as three boiler failures in one day, and on the same train, was a frequent occurrence, and trains were reduced to get over the road. Many locomotive dead-head miles were made; more coal burned with less results, due to leaks and cracks in the locomotive boilers.

So many questions enter into the Mechanical Department side of this question that it is difficult to express actual economies in terms of dollars and cents. Certain conditions will therefore be presented and some idea can then be gained as to what extent a betterment has taken place.

Between May, 1905, and July, 1907, 26 fireboxes were burned out and had to be renewed, but this does not include eleven rebuilt engines, of which two were changed in 1906, two in 1907, and seven in the fiscal year 1908-1909. The relief gained through the use of softened water has contributed in a very large measure towards the opportunity to remodel a practically obsolete type of locomotive.

The number of broken stay-bolts has decreased to a very large extent. In renewing flues, from one to three bucketsful of loose scale are now removed where formerly it measured from one to two dray-loads.

The effect due to the corrosive action of untreated waters taken from intermediate stations, are in a large measure removed. Such troubles as leaky mud rings, corners, seams, flues, tanks and places around stay-bolts; all are running repairs.

The best exhibit is a statement of locomotive mileage based on the installation of a new firebox or the resetting of tubes. It should be stated by way of explanation that before the water softeners were installed, a locomotive after running 34,000 miles was ready for new fireboxes or new side sheets. Since installing the softeners, and as soon as a partial recovery was made from previous conditions, the expected service has been raised to 50,000 miles—this with some water stations where untreated water is still taken.

At the end of March, 1909, there are ten locomotives ready for the shops, but if 34,000 miles had been the engine mileage limit for this year, the total number would be 26—a saving of more than 60%.

According to further reports made by Mr. Miller, it was found necessary previous to installing the softeners, to constantly employ twelve boilermakers in the St. Augustine shops alone, all of them being required to put in a great deal of overtime on the work, for which they received 1½ times their regular hourly rate of pay. After the installations had been made and a sufficient time had passed to allow the benefits to show up, it was found possible to permanently take off eight of these boilermakers from repair work necessitated by water conditions, and to do away with all overtime work. Estimating on a very conservative basis of $3.75 per day, per man, or $30 per day for 300 working days to the year, this meant a very direct annual saving of at least $9,000 in their St. Augustine shops alone. This point should be taken into consideration with the point made by Mr. Miller that in the fiscal year 1908-1909 they were able to remodel seven locomotives as compared with two each previous year.

From the time of making the original installation at East Mayport up to time this article is written, the builders responsible for their proper operation have not been called upon to furnish a single dollar's worth of repairs or replacements. This water-softening system as adopted by the Florida East Coast Ry. was designed by the American Water Softener Co., of Philadelphia, which did the entire work of installation, including all foundation and pipe work and housing.

Engineering Instruction at the Imperial Pei Yang University, Tientsin, China.*

By WALTER H. ADAMS.†

The object of this paper is to give an idea of the work in engineering education that is being done in China at the present time. This paper is confined to the Pei-Yang University—as it is the one the writer is most familiar with—but further description will be given in future papers. This paper will be confined entirely to the engineering work of the university.

The Imperial Pei-Yang University, first organized in 1895, and reorganized in 1902, is situated in the province of Chili just outside the limits of Tientsin, the largest city in North China and the port of the capital, Pekin. The university, although called imperial, is really a provincial university, as it receives all its support from the provincial government of Chili Province.

Money to carry on the work of the university has been granted quite freely by the various viceroys of Chili Province, who have been much interested in the work which has been done. The courses of study and method of government, however, are under rules given by the Imperial Board of Education in Pekin. All the students are supposed to be graduates of the provincial high school at Pao-Ting-Fu, in the same province.

Faculty.

The teaching staff is now composed entirely of Americans and Chinese. The first president of the reorganized university was an American, Dr. C. D. Tenney. Other nationalities have been represented in the faculty at various times to teach languages, but all such work is now abolished. Our present president, Mr. Wang Shoh-lian, although he received his education in England and never has visited America, has recruited the faculty entirely from American institutions. The result is a faculty of ten men who come from all parts of the United States, although the majority are from the Eastern States. Harvard has two representatives in the law department, Massachusetts Institute of Technology one each in the civil and mechanical engineering departments, the University of California two in the civil engineering department, Columbia and Leland Stanford universities one each in the mining engineering department, and Johns Hopkins University one in the law department. There are in addition a number of Chinese teachers. One of these is an assistant professor in civil engineering and conducts his classes in English. The others are not connected with the engineering departments and have no knowledge of English.

Courses of Instruction.

All the university work, with the exception of Chinese classics, is conducted in English. The present courses in engineering, as approved by the board of education, are three-year courses in civil and mining engineering. The subjects taught, except Chinese classics, are purely technical with no attempt to give culture studies. Therefore it is possible to give all the essential work in an American technical course in the three years. Much better work, including culture studies, could be done in a four-year course, but the board requires the work to be completed in three years.

The courses of study are very similar, both in subjects and hours allowed, to courses in the various American technical schools. Exactly the same text-books are

*Abstract from a paper presented at the Madison, Wis., meeting, June, 1910, of the Society for the Promotion of Engineering Education.

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ilsed as in the American institutions. The quality of the work compares favorably with that the writer has seen in the smaller American institutions, but is not so thorough as the work in the larger ones such as Massachusetts Institute of Technology, Cornell, Columbia and some others.

The courses in engineering practice in civil engineering have been given by summer school work in railway and hydrographic surveying. The summer school term is 2½ to 3 weeks each summer. It is required of all civil engineering students. The courses in engineering practice in mining engineering have been given by trips of inspection to mines and mine survey work in mines kindly placed by the owners at the disposal of the university. This work has lasted for three to four weeks during the year and is required of all mining engineering students.

The subject of physics is not included in the curricula, as it is supposed to be given in the high school. Up to the present time it has been given, along with elementary chemistry, by the university faculty, but is given as a preparatory subject in a preparatory year. This preparatory year is not part of the regular work and will be omitted as soon as the secondary schools reach a higher standard. Mathematics through the calculus has also been given in this preparatory year and later will be given in the high school.

The university is not allowed to give degrees. After completing the courses at the university the students go to Pekin to take a series of examinations covering the work they have done. (No one knows just what the examinations will be like as it is a new regulation.) All the drawings, notes and examination papers given at the university are sent to Pekin at the same time. If the students pass these examinations, they are granted Chinese degrees by imperial rescript. The passing mark required in the examinations is 60%.

Buildings and Equipment.

The buildings of the university comprise 39 buildings, scattered over an area of 1,500 ft. by 800 ft. Six of these are two stories in height and the rest are one story. The two-story buildings are four double professors' houses, the president's house, and the main building, which has 25 rooms. The professors' houses are heated by furnaces and the main building is heated by exhaust

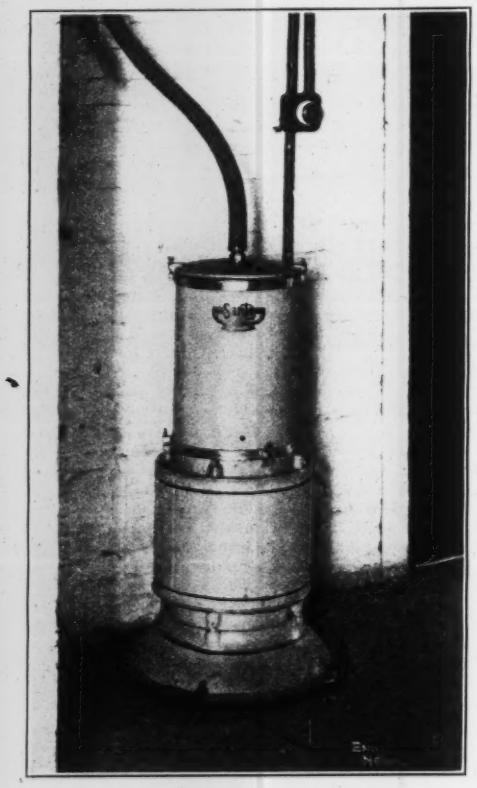

Fig. 1. The Keller Duplex Vacuum Cleaning Machine Installed.

steam from the lighting plant. The rest of the buildings are heated by stoves.

The equipment for instruction is the best of any belonging to the imperial universities in China, if not the best in China. (Some of the missionary colleges have very good equipment.) The equipment is much better than that of some American universities I could name.

The physical laboratory has a complete equipment for 25 students in a strong course of advanced high school physics. The apparatus is sufficient for tests in mechanics, hydraulics, heat, light, sound, optics, electricity and magnetism. The chemical laboratory has been remodeled this past year and now has two large rooms with the best modern equipment imported from America and Germany. The apparatus includes a gas plant for making gas for the laboratory. The laboratories have desk room for 50 students at one time.

There are two large well-lighted drawing rooms with individual desks to accommodate 75 students at one time. The surveying department has a large assortment of the best American instruments, consisting of rods, chains, tapes, levels, transits and plane tables. Twenty students can be sent out in the field at one time.

The testing materials laboratory has one 50,000-kg. Riehle universal machine, one 30,000-kg. Riehle hydraulic transverse machine, both with power drive. There are sufficient scales, molds, etc., to accommodate eight students at one time in cement and concrete mixing and testing. In addition there are the usual assortment of small instruments necessary in any well equipped laboratory. A hydraulic laboratory has been started with a small steam pump, motor-driven turbine pump, water wheel, water turbine, water meters, pressure tank, orifices, weirs, nozzles and piping for the measurement of the flow of water in piping. A modern water meter for gaging the velocity of water in rivers belongs to the laboratory. In addition there are the storage tank for water, scales, weighing tanks, etc.

There are a small machine and wood-working shop and pipe shop for the use of the professors and to do small repair work around the university. These shops have a power lathe, drill press, grindstone, hack saw, complete outfit of small tools, work benches, and pipe-fitting machinery. Power is furnished by a small gasoline engine.

The mining department has a museum containing a collection of the common minerals from all over the world, also a small collection of jewel stones, fossils and the shells of living animals. For petrographic work there are two lathes, for cutting and grinding rock slides, and four microscopes. In addition there is a mine tunnel 300 ft. in total length, including bends, of 5-ft. × 6-ft. 6-in. cross-section. This tunnel is timber lined and has two shafts leading to the surface. It is placed 15 ft. below the surface of the ground. The metallurgical department has the following equipments: Six Denver fire-clay double-muffle furnaces, two Ainsworth Culton balances, accessories for assay work, one small reverberatory furnace, one small cyanide plant for the treatment of gold ores, one small filter press, metallographic microscope, pyrometers and calorimeters for the investigation of fuels. These two departments have three projecting lanterns, two of which require electricity and one small one requires kerosene. One of the large ones is the largest model reflectoscope.

The university has its own lighting plant consisting of two Babcock and Wilcox boilers, without superheaters, and two 25-HP. Buffalo Forge Co.'s horizontal engines direct-connected to 15-KW. Siemens direct-current, 110-volt generators. In addition to the ordinary auxiliaries there is a storage battery to supply current part of the time.

By next summer it is hoped to have our own water system consisting of filtration plant, storage tank and distribution system.

The library is small at present and is housed in a very poor building. It contains all the leading engineering magazines, but has very few books. At present we do not have more than 500 books on engineering in the library. The university is buying books rapidly and within two years the library will have copies of all the engineering books of any value. A new fireproof library building is to be built within two or three years.

The Students.

The school year is ten months, divided into two terms. Recitations are held six days in the week with recitation hours from eight to twelve and one to four. The total number of hours assigned per week varies from 30 to 35. This is much higher than the American average and means less time for preparation and more work in the class room. Every student is expected to spend the time between 7 and 10 p. m. in study, and as much more time as he thinks is necessary.

The students live at the university and are not allowed to be absent from any recitations without special permission. A certain percentage is deducted from the yearly average for each hour of absence. The university supplies all books, drawing materials, chemicals and other supplies free of charge, and the students are allowed to retain their books upon payment of half price upon leaving the university. Originally the students were paid to attend the university, but now the payments have been stopped and a small fee is charged. The fee is to be raised as soon as the students are able to pay a larger one.

The students have a large, well-equipped gymnasium and athletic field. They receive instruction in athletics and games twice a week from an American Y. M. C. A. teacher. They are interested in tennis, basket ball, association foot-ball and track events. Base-ball and collegiate foot-ball do not seem to interest them. The athletic work is not compulsory.

At present it is practically impossible for a student to enter the university much under 23 years of age, so the average age will continue at 24 to 25. This is higher than the American average.

The number of years that English has been studied [a table, not included in this abstract, shows averages of from 7.5 years for the freshmen to 9 years for the seniors.—Ed.] is interesting, since all the work is conducted in English and the students are expected to take notes just as in any American college. The students cannot understand a lecture if it is delivered rapidly, but most of them have no difficulty if it is delivered slowly and distinctly. They have a better knowledge of technical English than they have of ordinary conversation. It requires six to eight years preliminary study of English to be able to do the work of the university and nine to ten years are better.

All but four of the 73 students enrolled in the university are from provinces along the coast, and those four are from provinces through which passes the Yangtze River, the main artery of commerce to the interior. This shows the fact that foreign education and methods have not penetrated very far at present, but the foreign influence is gradually going inland and new government schools, arranged according to foreign ideas, are being established continually.

This sketch of the Imperial Pei-Yang University shows that China has made a start in engineering education. The beginning is small but the prospects are good for a large amount of excellent work in the years to come. At present we cannot secure students with the proper training, so our number is small. It seems from the outlook now that this condition will exist for two or three years more and then we will have more students than we can handle with our present equipment.

A Duplex Vacuum Cleaning Machine.

The general principle of operation found in many successful vacuum cleaning machines is disclosed by examination of the accompanying figures. The particular design therein shown has, however, the novelty of having two diaphragm air pumps driven by a single motor, to decrease

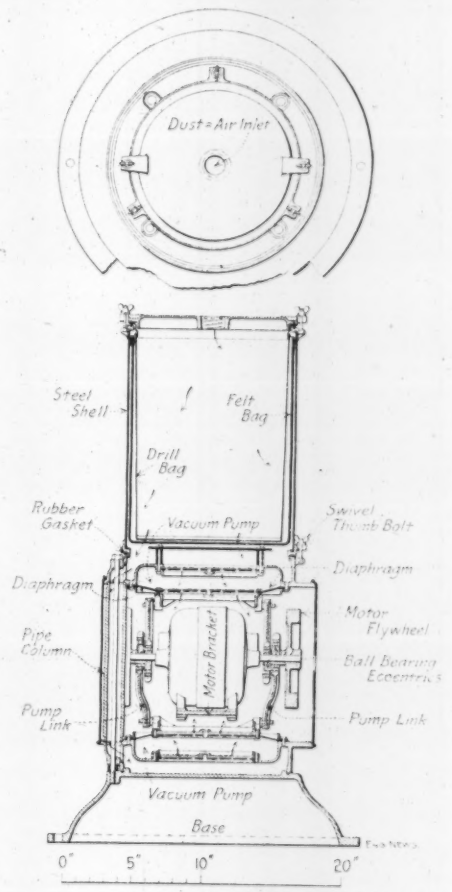

Fig. 2. Details of the Keller Duplex Vacuum Cleaning Machine.

the size for a given capacity or to increase the capacity for the same size.

On a broad circular cast-iron base is mounted the first air pump; the second pump is supported on four pipe columns above the first. The driving motor, of ¼-HP. capacity, is supported on a bracket midway between the pumps. The shaft of the driving motor is made unusually heavy and it rests in extra long bearings in the motor frame. The motor shaft is extended at both ends

and carries two ball-bearing eccentrics and a flywheel. Each pump is worked by two links which run from proper eccentrics. The working parts are thus arranged for maximum simplicity and efficiency of transmission and it is claimed that tests have shown that 20 to 25% more work can be secured than with other types of drive which have been tried. This helps to keep the size of the motor small.

It is desirable to limit the size of the motor to ¼-HP. so that it may operate directly upon ordinary lighting circuits, yet conforming with the requirements of the National Board of Underwriters and without special wiring. The ordinary snap or push-button switches may then be used to start the motor from any part of the building in which it may be installed as no special controlling or starting device is demanded.

The operating mechanism, just described, is enclosed by a sheet-steel cylinder, 15½ ins. in diameter and 12⅜ ins. high. Above this, but supported by the four pipe columns forming a frame with the two pumps, is the dust collector. First there is a sheet steel cylinder fastened to the frame by three swivel thumb-bolts which grip through slots in the ring around the bottom of the dust chamber. In the inside of the steel shell is hung a heavy felt bag, 11½ ins. in diameter and the full length of the shell. Inside this, in turn, is the dump bag of closely woven drilling 11 ins. in diameter and 15 ins. long. The steel shell is fitted into a stiffening casting at top and bottom and is sealed to the frame with a rubber gasket. The felt bag is fitted to the shell by a spring ring while the supporting ring for the drill dump bag and the cover both carry a gasket, which gaskets seal the bag, shell and cover together. The connection to the house piping, for this machine is not portable and there must be cleaning service pipes, is made with a 5-ft. rubber hose.

The dust-laden air is relieved of its burden in the upper chamber and passes, in part, directly to the upper diaphragm pump and, in part, down the pipe columns to the lower pump. After passing through the pumps it is blown out around the motor and escapes through an opening in the casing.

No special foundation is required nor are water and sewer connections necessary. A connection to a chimney or vent pipe is not needed, although such might be provided in special cases where the presence of pathogenic germs in the dust was suspected.

The machine described is made by the Keller Manufacturing Co., of Philadelphia, to which concern we are indebted for the information used in preparing this article.

FIRE DESTROYED THE ROUNDHOUSE and machine-shops of the Chicago & Northwestern Ry. at Chadron, Neb., on Aug. 3. Fifteen locomotives are included in the loss, which is estimated at $400,000.

THE CANADIAN PACIFIC STEAMSHIP "Princess May," from Skagway, Alaska, for Vancouver, B. C., ran on the north reef of Sentinel Islet on Aug. 4 and sank within two hours. Eighty passengers and their baggage were safely removed.

FOREST FIRES IN MONTANA AND IDAHO on the national forest reserves have become so serious that the government has 1,400 men engaged in fighting them. The loss to standing timber is estimated at $500,000, and adjacent timber valued at $3,000,000 is threatened.

AN EXPLOSION OF CORN DUST occurred at the works of the Corn Products Refining Co., Granite City, Ill., on Aug. 7. The explosion was on the sixth floor of a building where several workmen were engaged in sacking the corn dust as it came from the refining plant, about 100 ft. away. Two men were killed and seven others fatally injured.

A FREIGHT TRAIN WRECK occurred on the Delaware, Lackawanna & Western R. R. near Stroudsburg, Pa., on Aug. 5. The locomotive with 61 cars ran away on nine-mile grade, and on rounding a curve at the foot of the grade, the breaking of a flange on one of the locomotive driving wheels caused a serious wreck. Four of the cars were loaded with linseed-oil cakes which, becoming ignited, caused an almost total loss of the train by fire.

A HEAD-ON COLLISION between a passenger train and a light engine on the Northwestern Pacific near Ignacio, Cal., caused the deaths of 13 persons and seriously injured 12 others on Aug. 9. The accident occurred at a curve when the passenger train was traveling at the rate of about 40 miles an hour. Nearly all the passengers killed and injured were in the smoking car which was telescoped by the baggage car in front.

THE PENNSYLVANIA R. R. 18-HOUR TRAIN from New York to Chicago was derailed at Canton, Ohio, at 2 o'clock a. m., Aug. 7. The accident is said to have been caused by the dropping of the brake attachment on the locomotive. The locomotive did not leave the rails, but the tender and train of six Pullman cars were derailed and two of the Pullmans thrown crossways of the tracks. The Pullmans were of steel construction and beyond the breaking of glass were not seriously damaged. None of the passengers were seriously injured in spite of the severe shaking up they had received.

AN ELEVATED RAILWAY ACCIDENT under peculiar circumstances occurred in Boston, Mass., at one o'clock in the morning of Aug. 4. The regular trains had ceased running for the night when an empty four-car train, near the Bartlett St. yards getting beyond the control of the motorman, ran at full speed along Washington St. towards Dudley St. At this point there is a sharp curve and the first two cars left the rails, one falling to the street was smashed to pieces and the other caught on the roof of the Eliot National Bank. The motorman was fatally injured and died in a few hours.

A SLIDE IN A DEEP ROCK CUT wrecked a fast fruit train of 17 refrigerator cars on the Erie R. R. near Howells, Orange County, N. Y., on Aug. 5. The cut, locally known as Rock Cut, is about 50 ft. deep at the point where the wreck occurred. Heavy rains on the previous night had loosened the sides of the cut and a great mass of material fell on the track but a few minutes after the cut had been inspected by a track walker. The train, traveling at nearly 50 miles an hour, crashed into the debris, entirely wrecking the locomotive and ten cars. Three trainmen were killed.

PANAMA CANAL EXCAVATION during July totaled 2,406,288 cu. yds., for the second time this year dropping below the 100,000 cu. yd. daily average, with an average of 96,252 cu. yds. for each of the 25 working days. The rainfall for the month was 15.65 ins. The amount of concrete laid during July was 131,653 cu. yds., against 124,214 cu. yds. in June, and 654,095 cu. yds. of fill were placed in dams, against 664,155 cu. yds. in the previous month.

THE LA SALLE ST. TUNNEL under the Chicago River at Chicago is making good progress, but the actual tunneling will be confined to a portion of the approaches, the river section being formed by sinking a twin-tube caisson, on the same system as that employed for the Detroit River Tunnel. The steel caisson (now being built at a shipbuilding yard) will be 41 ft. wide, 28 ft. high and 278 ft. long. A channel will be dredged across the river bed, the upper part being taken out by a dipper dredge and the lower part by a clam-shell dredge. Near each end will be built a concrete seat for the caisson. The caisson will be towed to the site, and while moored near the bank will have the concrete filling placed between the inner and outer shells. It will then be swung round across the river, and when in proper position valves will be opened to flood the caisson and sink it. When finally landed, quantities of sand will be dumped into the sides of the trench so as to form a solid filling under and around the caisson. The approaches will be double-track tunnels, the portions adjacent to the river being driven by headings, while the opposite ends will be built in open cut. These cuts are now nearly finished, the sides being lined with steel sheet piling (on the line of the street curbs) and braced by heavy timbering. The methods of construction were designed by Mr. Max Landguth, Superintendent for the contracting firm, the M. H. McGovern Co., of Chicago.

LITIGATION AGAINST THE BRONX VALLEY sewer, now being built by the Bronx Valley Sewer Commission, to serve a number of vicinities north of New York City, was recommended by the Metropolitan Sewerage Commission of New York in a communication dated July 25, 1910, addressed to Hon. William J. Gaynor, Mayor of New York. The sewer, which has been under construction for some time, will begin at the north city line of White Plains and pass through Scarsdale, Tuckahoe, Bronxdale, and part of Yonkers and Mount Vernon. Its diameter will be 3½ ft. at the upper and 8½ ft. at the lower end, and its length 14 ft. Storm water will be excluded. It is designed to serve a total area of 35 sq. miles. The present population is about 30,000, and the ultimate population is estimated at 850,000. The estimated volume of sewage discharge is 3,000,000 gals. at the outset, increasing ultimately to 90,000,000 gals. The estimated cost of the system up to the time of opening, including land and incidentals, is $2,250,000. The outlet is to be into the Hudson River, about 300 ft. north of the joint boundary line between the cities of New York and Yonkers. Here it is proposed to carry two 48-in. c.-i. pipes out 500 ft. into the river and terminate them 40 ft. below the surface. Reliance is to be placed upon dispersion and dilution of the sewage by the water of the river. The Metropolitan Sewerage Commission, in the report mentioned at the beginning of this paragraph, claims that such a discharge of sewage will produce a local nuisance and add unwarrantably to the present and prospective sewage burden placed upon the water surrounding New York City. It urges that the discharge of crude sewage from the Bronx Valley at the point indicated "would benefit one section of the metropolitan district at the expense of the others." It also urges that by means of special legislation the control of sewage discharge from the Bronx Valley was taken away from the State Department of Health, which department has control of this matter elsewhere in the state. For these and other reasons given in the report, the Commission urges that the City of New York apply to the U. S. Supreme Court for permission to intervene in the pending suit brought by the United States against the City of New York and the Bronx Valley Sewerage Commission.

STATE AND MUNICIPAL BONDS were sold during the month of July having a par value of $34,501,536. This, according to the records of the "Financial Chronicle," is the largest output for municipal bonds in any corresponding month, except July, 1909. The total for the seven months of this year falls considerably short of the previous record, being in round numbers $194,000,000 compared with $227,000,000 last year. With that exception, however, it is the largest total for any corresponding period. The sales during July included $11,000,000 State of New York bonds, $5,000,000 City of Philadelphia, about $4,000,000 City of Boston and $1,500,000 City of Los Angeles. In all 239 municipalities sold certificates of indebtedness during the month.

COUNTY HEALTH LABORATORIES have now been established by Ontario, Steuben, Warren and Monroe counties, N. Y., and contracts for work to be carried on in laboratories of other counties have been made by Yates and Onondaga counties. All this is in accordance with Chap. 255, Laws of New York, 1908. In the course of the paper on "The Function of County Laboratories in the Preservation of the Public Health," by Charles W. Hennington, M. D., Rochester, N. Y., published in the "Monthly Bulletin of the New York State Department of Health," for July, 1910, the nature of the work undertaken by the Monroe County Laboratory (Rochester, N. Y.) is thus stated by means of the quotation from the resolution of the County Board of Supervisors:

> The special and stated function of the laboratory is to be the performance, among other things, of sputum examinations for tuberculosis, throat cultures for diphtheria, blood-serum tests for typhoid fever, and other microscopic and chemical examinations, when these do not come in conflict with the work of private individuals, but always when the interest of the community warrants the necessity of the same.

THE SANITARY CONDITIONS OF THE OSWEgatchie River drainage area have been investigated by the New York State Department of Health, and are reported on briefly in the bulletin of the Department for July, 1910. The river rises in St. Lawrence, Hamilton and Herkimer Counties, N. Y., and flows northerly to Ogdensburg on the St. Lawrence, and has a sparsely populated drainage area of 1,609 sq. miles, including seven villages, with a total population of 8,563. The only village with more than approximately 1,000 inhabitants is Gouverneur, the population of which is 4,229. Gouverneur is the only village on the drainage area which has a public sewerage system of any extent discharging into the river. Typhoid fever "is continuously present in excess in Gouverneur," and this condition seems to be reflected by the vital statistics of Ogdensburg, which show an average typhoid death rate of 41.2 per 100,000 for the 20 years between 1887-1906. Some trade wastes from paper and pulp mills reach the river. The report states that a purification plan for Gouverneur and reasonable restrictions on the discharge of sewage into the river from other villages "would easily maintain the good quality of the river for all future use."

THE METROPOLITAN SEWAGE FARM OF MELbourne, Victoria, and vicinity, included 8,847 acres of land in 1909. The original cost of the land was $85 per acre, or a total of about $752,000. In addition about $1,420,000 have been spent on works for distributing the sewage, thus bringing the cost of the farm up to June 30, 1909, to a total of some $2,174,000. About 28,000,000 U. S. gals. of sewage per day are applied to the farm. The effluent from the sewage farm is discharged into Port Phillip Bay "in a clear and transparent condition." The farm is "laid down

with prairie grass and lucerne, on which sheep are depastured." During the fiscal year 1908-9, 32,157 sheep were bought at a total cost of $82,853. Other expenses amounting to $15,882 brought the total expenses for the year up to $98,736. During the same year 22,047 sheep were sold. The proceeds, together with receipts for wool and skins, amounted to $107,674. The profit on the sheep for the year, according to the "Official Year Book of the Commonwealth of Australia," from which the foregoing information has been taken, amounted to $29,300. The report does not state whether capital charges were taken into account.

A PIECE OF ROAD BUILDING, more spectacular than permanent, was recently reported from Iowa. It is stated that after some months of preliminary arrangement 10,000 men began work upon what was virtually a continuous line of road extending for 300 miles across the state from Davenport on the Mississippi to Council Bluffs on the Missouri. In an hour's time, reports state, these men with the aid of teams, grading machines, scrapers, road drags and hand tools put this stretch of road in good condition from river to river.

ACCIDENTS ON STEAM RAILWAYS in the United States for the first three months of 1910 resulted in the death of 1,100 persons and injured 21,232. This was an increase of 466 killed and 6,110 injured as compared with the same period in 1909. The figures given include only employees on duty and passengers. On the electric railways 19 persons were killed and 669 injured during the first quarter of the present year. We quote from Accident Bulletin No. 35 of the U. S. Commerce Commission as follows:

> The total number of casualties in this quarter is swelled by two great disasters, an avalanche in the state of Washington and a derailment in Iowa, both in the month of March, in these two disasters 141 persons were killed and 52 injured, in other respects the present record shows no remarkable differences as compared with the corresponding quarter one year ago (Bulletin 31) bearing in mind the fact that Bulletin 31 represents a time when there was still an abnormally low volume of traffic on many roads.

A PATENT FOR WATERPROOFING CONCRETE by a special application of the colloidal theory of the setting of cement has been granted Mr. Edward Thomas, of Haverford, Pa. Some time ago it was announced that the addition of a colloid, such as finely-divided clay, to a mixture of sand and cement, would give a dense mixture of the set mortar which would be much less permeable than an ordinary mix. In Mr. Thomas' patent the colloidal matter in the mixture is supplied by colloidal cement. If cement is mixed with many times its weight of water there occurs a gelatinous precipitate, which is greatly increased in bulk over the original cement and which by itself will not set hard except under heavy pressure; this precipitate is known as colloidal cement. The Thomas method takes this large quantity of water into which a small amount of cement has been stirred, and keeping it agitated so that the precipitate cannot form, uses it for the mixing water of the concrete. It is claimed that concrete so made in mass is quite watertight. It has been found that from 4 to 6 oz., avoirdupois, of cement should be used to each gallon of water in forming the colloidal mixture, and then any ordinary proportioned mix of concrete may be made, with this water as the mixing agent.

A somewhat similar process was patented in 1907 by Mr. Ludwig Hatschek, but the application there was to thin concrete plates, such as shingles, in which asbestos fiber is mixed to give a generally fibrous nature to the slab. The set is obtained under high pressure.

Personals.

Mr. Charles A. Hammond, M. Am. Soc. C. E., formerly Resident Engineer of the Mount Vernon, N. Y., sewage disposal works, has been made Manager of the same.

Mr. J. O. Gordon, Superintendent of the Chicago Great Western Ry. at Des Moines, Iowa, has also been appointed Superintendent of the Leavenworth Terminal & Bridge Co.

Mr. T. H. Hayden has been appointed Superintendent of the Kentucky & Indiana Bridge & Ry. Co., at Louisville, Ky., under Mr. W. M. Mitchell, Manager and Chief Engineer.

Mr. Frederick H. Lewis, M. Am. Soc. C. E., has resigned as General Manager of the Standard Portland Cement Co., Leeds, Ala., to spend some months in travel. Mr. Lewis continues as Vice-President and Director.

Mr. M. H. Peck, Assoc. M. Am. Soc. C. E., Professor of Civil Engineering at the Imperial Pei-Yang University, Tientsin, China, has been granted one year's leave of absence, which he intends to spend in the United States.

Mr. J. B. McIntosh, lately Engineer-in-Charge of the newly completed Tooele plant of the International Smelting & Refining Co., has resigned to become Superintendent of Construction of the Garfield plant of the American Smelting & Refining Co.

Mr. E. E. Thum, lately the chief civil engineer for the Tooele plant of the International Smelting & Refining Co., has been transferred to the position of Engineer for the Boston & Montana Reduction Works of the Anaconda Copper Mining Co.

Mr. Onward Bates, Past-President, Am. Soc. C. E., has been made a trustee of the Chicago Bureau of Public Efficiency. This bureau is a semi-public organization appointed by the City Club of Chicago to take charge of a fund of about $100,000, which was privately raised for the purpose of investigating public affairs.

Mr. R. N. Begien, Assoc. M. Am. Soc. C. E., formerly Division Engineer of the Baltimore & Ohio R. R. at Philadelphia, Pa., has been made Assistant to the Chief Engineer, with headquarters at Baltimore, Md. Mr. Begien has been with the Baltimore & Ohio R. R. since 1903 when he began as an assistant engineer in the construction department.

Mr. J. M. Gorman has been made Assistant General Manager of the Philadelphia Rapid Transit Co. Mr. Gorman is an electrical engineer who has previously been Superintendent and Chief Engineer of the Pittsburg & Duquesne Traction Co., Assistant General Manager of the Havana Electric Railway Co., and more recently associated with the Mexican Northern Power Co. of Mexico.

Maj. Charles Hine, Special Agent of the Union and Southern Pacific Rys., whose work on the unit system of organization for those and other Harriman lines was described in Engineering News of March 3, 1910, has been asked by President Taft to make a preliminary examination of methods and organization in various executive departments of the government, with a view to more efficient administration.

Mr. Frank T. Fowler, Superintendent of Streets, Chicago, Ill., has resigned. His appointment was made last February by Mayor Busse, notwithstanding the civil service laws which require the position to be filled as the result of a civil service examination. In the examination which was held, Mr. John T. Fetherson, M. Am. Soc. C. E., of New York City, obtained the highest rank but waived appointment because of litigation brought against the civil service commission by ward superintendents.

Obituary.

Daniel L. Hurlburt, an electrical engineer and inventor of New York City, died at his home on Aug. 2. Mr. Hurlburt was born near Troy, N. Y., in 1832.

James M. Hicks, a civil engineer and patent lawyer of Summit, N. J., died on Aug. 3 from Bright's disease. He was with the Novelty Iron Works of New York during the Civil War and superintended the construction of the gunboat "Miantonomoh," one of the earliest of its kind.

J. Edward Simmons, a New York City banker and former President of the Panama R. R. Co., died at Mohonk Lake, N. Y., on Aug. 5. Mr. Simmons was a director of many corporations and was prominent in public life. He was the first President of the Board of Water Supply which is building the Catskill reservoirs for the City of New York. He was prominent in the development of the College of the City of New York and of several charitable institutions.

Washington Jones, for many years one of the most prominent engineers of Philadelphia, Pa., died at his home in that city on July 30. Mr. Jones was born in Philadelphia on Feb. 22, 1822, and was a grandson of William J. Jones, an officer of the Continental Army. He had a common school education. He was Chief Draftsman of the Penn Works, manufacturers of marine engines; Superintendent of the Port Richmond Iron Works; Assistant Superintendent of the Southwark Foundry, 1861-1866; General Superintendent and Constructing Engineer for the Port Richmond Iron Works, 1866-1891, and a director of the American Dredging Co. He was a member of the American Society of Civil Engineers, American Society of Mechanical Engineers, American Institute of Mining Engineers, and at the time of his death was a Vice-President of the Franklin Institute of Philadelphia.

Oswald F. Jordan, inventor of the Jordan spreader car and other railway machinery and appliances, died Aug. 1 at the age of 57. He was born at Berwick-on-Tweed, England, but was brought to this country when a child. He entered railway service in 1864. He was Roadmaster of the Michigan Central Ry. from 1881 to 1892, when he was appointed Division Superintendent, which latter position he held until his resignation in 1898. A few years ago he organized the O. F. Jordan Co., of Chicago, for handling his inventions. The most important of these was his air-operated spreader car, which was described in our issue of Sept. 17, 1908. This has been used very extensively on railway work and also on the Panama Canal. His bridge guard, consisting of three lines of rails laid between and parallel with the track rails, is used as standard by the Michigan Central Ry. and the Canadian Pacific Ry., and a spring-rail frog of his design has been used on the former road.

Engineering Societies.

COMING MEETINGS.

TRAVELING ENGINEERS' ASSOCIATION.
Aug. 16-19. Annual convention at Niagara Falls, Canada. Secy., W. O. Thompson, New York Central Car Shops, East Buffalo, N. Y.

LEAGUE OF AMERICAN MUNICIPALITIES.
Aug. 23-26. Annual convention at St. Paul, Minn. Secy., John MacVicar, Des Moines, Iowa.

LAKE SUPERIOR MINING INSTITUTE.
Aug. 24-26. Annual meeting at Ironwood, Mich., and Chicago, Ill. Secy., A. J. Yungbluth, Ishpeming, Mich.

AMERICAN PUBLIC HEALTH ASSOCIATION.
Sept. 5-9. Annual meeting at Milwaukee, Wis. Secy., W. C. Woodward, Washington, D. C.

ASSOCIATION OF EDISON ILLUMINATING COMPANIES.
Sept. 6-8. Annual meeting at Thousand Islands, N. Y. Asst. Secy., Walter Neumuller, 55 Duane St., New York City.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.
Sept. 6-9. Annual convention at Rochester, N. Y. Secy., Frank P. Foster, Corning, N. Y.

MICHIGAN GAS ASSOCIATION.
Sept. 8-12. Annual meeting on board steamer sailing from Detroit, Mich. Secy., Glenn R. Chamberlain, Grand Rapids Gas Light Co., Grand Rapids, Mich.

MASTER CAR AND LOCOMOTIVE PAINTERS' ASSOCIATION.
Sept. 13-16. Annual convention at St. Louis, Mo. Secy., A. P. Dane, Reading, Mass.

ROADMASTERS AND MAINTENANCE-OF-WAY ASSOCIATION.
Sept. 13-16. Annual convention at Chicago, Ill. Secy., Walter E. Emery, Chief Engineer, Peoria & Pekin Union Ry., Peoria, Ill.

COLORADO ELECTRIC LIGHT, POWER AND RAILWAY ASSOCIATION.
Sept. 21-23. Annual convention at Colorado Springs. Secy., J. C. Lawler, P. O. Box 938, Colorado Springs.

NEW ENGLAND WATER-WORKS ASSOCIATION.
Sept. 21-23. Annual convention at Rochester, N. Y. Secy., Willard Kent, Narragansett Pier, R. I.

NATIONAL IRRIGATION CONGRESS.
Sept. 26-30. Annual meeting at Pueblo, Colo. Secy., Arthur Hooker, Pueblo, Colo.

AMERICAN STREET & INTERURBAN RAILWAY ASSOCIATION.
Oct. 10-14. Annual convention at Atlantic City, N. J. Secy., H. C. Donecker, 29 West 39th St., New York City.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Oct. 11-14. Annual convention at Erie, Pa. Secy., A. P. Folwell, 239 West 39th St., New York City.

RAILWAY SIGNAL ASSOCIATION.
Oct. 11-13. Annual meeting at Richmond, Va. Secy., C. C. Rosenberg, Bethlehem, Pa.

AMERICAN ELECTROCHEMICAL SOCIETY.
Oct. 13-15. Annual meeting at Chicago, Ill. Secy., Jos. W. Richards, Lehigh University, South Bethlehem, Pa.

AMERICAN SOCIETY FOR TESTING MATERIALS.—As reported in our issue of July 7, 1910, p. 27, Committee D-4 "On Standard Tests for Road Materials" reported at this year's convention a specification to be sent to letter ballot, but on account of a misunderstanding among the members of the Committee as to the exact wording of a portion of the specification, this sending to letter ballot was withheld awaiting the unanimous written approval of the report by the Committee. It has just been announced by the Secretary of the Association that such unanimous approval can not be had and, as a result, the Standard Specifications on Road Material will not be sent to letter ballot this year.

LAKE SUPERIOR MINING INSTITUTE.—The 15th annual meeting will open at Ironwood, Mich., Aug. 24, and will include a trip to the steel works at Gary, Ind. At Ironwood, the day will be spent in visiting points of interest on the Gogebic iron range, and a business session will be held in the evening. At 11 p. m. a train will start for Chicago, where visits will be made to the Chicago & Northwestern Ry. shops and the plants of the Sullivan Machinery Co. and Joseph T. Ryerson & Son. In the afternoon the party will attend a baseball game, after which it will be taken by train to Gary, where a business session will be held after dinner. On Aug. 26, the plant of the Indiana Steel Co. will be visited, with a return to Chicago in time for the annual dinner at the Auditorium Annex.

NEW ENGLAND WATER WORKS ASSOCIATION.—The annual convention will be held at Rochester, N. Y., Sept. 21-3, with headquarters at Hotel Seneca. On Tuesday evening, Sept. 20, the local committee will hold a reception. On the following two days these papers will be presented: "Steel Pipe Lines," by Emil Kuichling; "Ice Formation," by Prof. H. T. Barnes; "Statistics of Growth of Income," by F. C. Jordan; "Depreciation of Water-Works and Methods of Accounting Therefor," by Leonard Metcalf, and "Investigations into the Transportation of Sand and Water in Pipe and Hose Lines," by Morris Knowles and James M. Rice. These papers will be discussed: "The Relation of Flies to the Transmission of Infectious Diseases," by Dr. Herbert D. Pease, and "Corrosion of Metals," by Robert S. Weston. The local committee is planning excursions to various points of interest for Friday, Sept. 23. Mr. Willard Kent, Narragansett Pier, R. I., is Secretary.